Popular Astronomy.

Vol. XXVI, No. 8. OCTOBER, 1918. Whole No. 258.

THE ORIGIN OF COMETS.*

ELIS STRÖMGREN.

The University of Chicago has greatly honored me by inviting me to give a lecture on an astronomical subject during my visit to this city.

When I left my country for the United States it certainly was not with the intention of teaching the American astronomers, but on the contrary in order to study and learn myself. American astronomy stands so high that a European astronomer always considers a visit to the United States as an important event in his scientific evolution. When I, to-day, have the opportunity of laying before this audience some results of my own researches in popular form, it is with a strong feeling that what I can offer you today is so very little compared to what I myself have received not only generally at American observatories but especially at the world-famous observatory of the University of Chicago.

All known comets are observed inside our solar system. Our sun is one of the billions of suns which together are called the Milky Way system, and in all probability our Milky Way system is only one of millions and millions again of similar systems.

Our little solar system consists of the sun, the planets with their satellites, and the comets. One of the planets is the earth, a small celestial body, which for most human beings is their whole world. The smallness of the earth and of our solar system in relation to the universe is a scientific matter of fact, which has been proved so long ago that it has become almost a truism. And still I think it worth while—in these times—to consider how insignificant everything human is, and how petty are our affairs.

---

* A popular lecture given at the University of Chicago November 9, 1917, by Professor Elis Strömgren, Director of the Observatory at Copenhagen, Denmark.

At the meeting of the British Association for the Advancement of Science, held in Manchester in the year 1915, the President of the Association told the following little story:

> An American astronomer, who possessed a powerful telescope, one night received a visit from an ardent politician. It was during a presidential election, Bryan and Taft being the opposing candidates, and feeling ran high. After looking at star clusters and other celestial objects, and having received answers to his various questions, the visitor turned to the astronomer and asked:
>
> "You tell me that every one of these stars is a sun like our own?"
>
> "Yes".
>
> "And that each of them may have a number of planets circulating around them like our sun?"
>
> "Yes."
>
> "And that there may be life on each of these planets?"
>
> The astronomer answered:
>
> "We cannot tell for certain, but it is quite possible that there may be life on many of them."
>
> After pondering for some time the politician rose and said: "It does not matter, after all, whether Taft or Bryan gets in."

I think this is a very good story; it throws a bright light upon the moral which can be drawn from the study of celestial problems.

Of the different celestial bodies we will today occupy ourselves with *the comets*. We will limit ourselves to one question: *Whence do the comets come, and whither do they go? Are they part of our solar system, or are they birds from afar, which only for a short time linger around our little nest?*

As long as man on the whole has been able to meditate upon things above his immediate range, these questions have always possessed a great attraction for the imagination. For a long time the opinions of the astronomers on this point have been divided and changing, but to-day we are able to give a positive answer to the question of the origin of comets.

We are all familiar with the appearance of a comet. The principal parts are the head, with the nucleus within it, and the tail. But today we are not going to deal with the appearance or with the physical and chemical conditions of the comets. I am going to talk about the *origin* of comets, and this question is connected with the question of the *orbits* of the comets.

Until the days of Tycho Brahe it was believed that the comets were phenomena in the atmosphere of the earth. Tycho Brahe succeeded

in proving that the comets are celestial objects, but a real determination of the orbits of comets in space was first made after *Newton* had discovered his law of universal *gravitation.*

This law, the law of gravitation, is the basis for all computations of orbits of celestial bodies, and without an understanding of the contents of this law it is not possible to understand a discussion of the problem of celestial movements.

Popularly expressed and applied to astronomical problems this law says:

Wherever there are two celestial bodies, there always is a force of attraction working between the two bodies. And with regard to the intensity of this force, the law says that it is greater the bigger the two masses are and the closer they are to each other.

We are all familiar with the method by which one can demonstrate the effect of this force upon two heavenly bodies, for instance the sun and the earth.

The result is that the small body, the earth, must travel in an oval orbit around the large body, the sun.

Such *is* the orbit of the earth, and such *are* the orbits of the other planets also.

That the force of gravitation exists there is no doubt. It is there, and it is working all the time and everywhere, wherever there is matter.

By this force it is possible to explain all the motions of the celestial bodies, even to the finest details, *but* are we able to explain the force itself?

Here we touch upon the darkest point of the whole astronomical science.

How difficult this question is, was clearly illustrated a few years ago by a prominent English astronomer. While speaking of the attempts of modern physicists to construct models of atoms, which should be able to explain the different qualities of matter, he said:

"If a new model of the atom is put forward, we ask if it accounts for the Zeeman-effect, for chemical affinity, for the dispersion of light, and a host of incidental phenomena; but it would be considered *unfair* to suggest that it ought to account for the *one fundamental and universal property of matter, gravitation.*"

But the force *is* there. And we know how by the aid of this force we are able to explain the shape of the planetary orbits.

A mathematical investigation of the problem, however, shows that there is a possibility of two other kinds of orbits in the problem of two bodies.

The orbits we have spoken of are called *ellipses*.

The other two kinds of orbits which are possible in the problem of two bodies are called the *parabola* and the *hyperbola* (see Fig. 1).

The essential difference between these two kinds of orbits (parabola and hyperbola) on the one side, and the ellipse on the other, is that the ellipse is a closed curve, and the parabola and the hyperbola are open with branches of indefinite extent.

This means in other words:

> An elliptic orbit of a comet indicates that the comet belongs to our solar system; a parabolic or a hyperbolic orbit indicates that the comet comes from without, from interstellar space.

Thus the whole question of the origin of comets seems very simple: if we put together in a table all computed comet orbits, we find that there are a certain number of hyperbolas and parabolas and another number of ellipses; from which we might draw the conclusion that some of the comets have come from without and that some of them belong to our solar system.

Yes—the problem seemed to be very simple, and it was treated in this simple way until about twenty years ago.

But we are now going to see that the problem is in reality much more complicated.

When speaking about the "problem of two bodies" and the explanation of the orbits of the planets and the comets, we intentionally neglected one point which is of great importance when we have to make *exact* calculations.

We know how the sun's attraction causes a planet, for example the *earth*, to make an ellipse around the sun. We can in the same way show how the planet Mars follows a similar orbit around the sun.

But in reality, in addition to the attractions between the sun and the earth and between the sun and Mars, there is also a mutual attraction between the *earth and Mars*, and, despite its comparative insignificance, this force causes deviations from the purely elliptical orbits of the two planets. Such small deviations from the simple ellipse are called *perturbations*.

The computation of the *perturbations* in the motions of the planets has for two centuries been the chief problem in theoretical astronomy.

But now we arrive at the important point in the cometary problem.

The orbit, which is computed with the aid of the observations of a comet, is in fact only valid for a certain period of time—the period during which the comet has been observed, that is, in the vicinity of the perihelion of the orbit—for the obvious reason that the comet is

not visible from the earth beyond a certain distance from the perihelion, both coming and going (see Fig. 1).

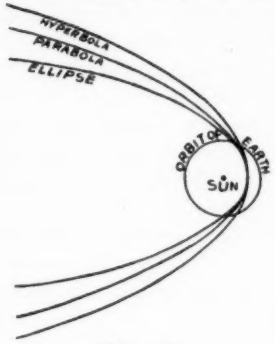


FIGURE 1.

In this way, with the help of a very small section of the orbit, one orbit after the other was computed. In the course of time we obtained a table of several hundreds of cometary orbits. And this table formed the basis for all conclusions drawn in regard to the origin of comets.

Nobody ever raised the question as to whether the innermost part of the cometary orbit really is a true expression of the way in which the comet *originally* entered into the interior parts of our solar system.

It was not until about twenty years ago that this simple question was raised: Have not the great planets of our solar system had a noticeable influence upon the orbits of the comets during the long time needed for coming into the interior parts of our solar system? Is it not possible that this influence can be so great as to change an originally elliptic orbit into a hyperbolic one and vice versa?

If this be the case, must not the problem of the origin of comets be taken up anew?

Let us look more accurately into the matter.

Amongst the various qualities which characterize an ellipse, a parabola, or an hyperbola, there is one which is particularly important for our problem. It is that which we might term *the degree of elongation.* It is called by astronomers and mathematicians the *eccentricity* of the orbit and is designated by the letter e.

In order to obtain a concrete impression, we give the following figures:

1. A circle has no elongation. We say the eccentricity $e = 0$.
2. The ellipse can for e have all possible values between 0 and 1.
3. The parabola has $e = 1$.
4. The hyperbola has e greater than 1.

If then with the aid of our observations we have calculated the orbit of a comet and obtained the result

$$e = 0.999500,$$

this would mean that the orbit is elliptic; and if we obtained the result

$$e = 1.000500,$$

this would mean that the orbit is hyperbolic.

Now amongst our calculated cometary orbits we really have a great many cases where the eccentricities lie in the neighborhood of unity,

the most a little less than 1, the remainder a little more. And we now know from the preceding what a fundamental difference there is from a cosmogonic point of view between the cometary orbits where the eccentricity is a little less than 1 and those cases where it is a little more. In the former case the comet would belong to our solar system —in the latter it would have come from the outside.

But now we again come back to our original starting point: that orbit which has been calculated by our observations, i.e., by the help of the innermost part of the orbit, cannot be exactly the same as that orbit which the comet had in the outer parts of the solar system.

Then calculate the perturbations and see what eccentricity the orbit had when the comet was far away.

This investigation has been made during the last twenty-two years*, and the results may be summarized in the following way:

If we follow the different comets backwards for a sufficient time, we find that there is not one single hyperbola left. Those comets, which in the interior part of the solar system have shown a hyperbolic orbit, have received this hyperbolic shape through the perturbations by the planets.

This is the answer to the question of the origin of comets: the comets belong to our solar system, and, where the astronomers previously believed they had to differentiate between *periodical* and *non-periodical* comets, we now only speak of *short-period* and *long-period* comets.

Here we have a piece of cosmogony, the cosmogony of comets. It carries us far back in time. Those comets that have the most extended orbits need hundreds of thousands of years to go around the sun.

But, as my audience knows, the astronomers have set up cosmogonic theories which carry us back into, not hundreds of thousands, but millions and billions of years.

The striking likeness between the orbits of the planets led to the famous Kant-Laplacian hypothesis.

The interesting features of the so-called *Spiral Nebula* led *Chamberlin* and *Moulton* to the planetesimal theory, a comprehensive sketch for the whole evolution of celestial bodies and systems of celestial bodies.

Such theories are extremely valuable in astronomy as stimulating to researches in various lines.

---

* For the development of the problem historically see "Publikationer og mindre Meddelelser fra Köbenhavns Observatorium Nr. 19".

The solution of the question of the *origin of comets*, which we have now put forward, relates to one single problem only. It does not suggest any extensive views or prospectives, nor does it take us either so far back in time as the general cosmogonic theories mentioned above. But our answer to the question of the origin of comets has another quality, which from a certain point of view gives to it a decided preference over most cosmogonic theories: we have arrived at the answer to our problem through exact computation, without any hypothesis and without any assumptions. The only basis for our computation was the law of gravitation, and nobody doubts the existence of this gravitation.

Various arguments against the theory of the comets belonging to our solar system have been put forward.

One has, amongst others, by the help of statistical methods, tried to discover systematic features in the movements of the comets. One has for example discussed the question as to whether the planes of the cometary orbits in space are grouped in a special way—or whether there are special points in the sky from which the comets appear to come preferably. One has believed that such peculiarities in the motions of the comets would show that the comets come into our system from the outside.

But for the first it has been demonstrated (by *Holetschek*) that a great mass of such peculiarities in the movements of the comets are only apparent—in that they can be explained from the conditions of observation from the earth, and for the rest we cannot on the whole imagine any systematic features in connection with the cometary orbits which are not explainable by the theory of the comets belonging to our solar system.

If for example it can be shown that the comets chiefly come to us from certain areas in the sky, it is quite unnecessary to suppose that the comets should have entered our system from the outside from peculiar places in space. It can be explained equally well by the very probable supposition that in places far out *in our nebula* there have existed concentrations of nebular matter which later have gravitated towards the center.

Against the positive proof of the comets belonging to our solar system which we have given today, the existence of such systematic features in the movements of the comets would therefore have no weight.

But now we will try to consider our question in its relation to longer periods of time and to current cosmogonic theories. We came to the

conclusion that all known comets are going in elliptic orbits around the sun, and we arrived at this result by an investigation based upon the hitherto calculated cometary orbits. Of course this does not preclude the possibility of a comet coming in from the outside—to-day or in ten thousand years—but up to now we have not been able to point out one single comet which has come from without—from interstellar space.

This is really a very strange result.

There is hardly any astronomer who doubts the leading idea in modern cosmogonic theories, that the celestial bodies and systems of celestial bodies have originated from nebulous matter.

It is quite natural that there still are in existence in our solar system, and especially in the outlying parts of it, such diffuse nebulous matter.

But why do we never discover any comets coming from the space *between the different solar systems*?

Is there no nebulous matter in the immense spaces which separate the different solar systems?

It really seems so, and we will try to indicate a possible explanation

---

I will show you a slide: (A globular cluster.)

Thousands or millions of stars gathered into a system of approximately globular form. Such a system is called a *globular cluster.*

Here is another photograph: (A Spiral Nebula).

A so-called Spiral Nebula. However, these spiral nebulæ are no nebulæ at all, but conglomerations of thousands or millions of stars.

We know that our own sun is one of millions of suns in a system which is called the Milky Way system, and there are many things which indicate that our Milky Way system is such a spiral nebula.

The distribution of the stars in the globular clusters is of an especially interesting nature: the stars are very much concentrated in the center of the cluster, and gradually thin out towards the outer regions.

Until a few months ago the astronomers had not been able to observe a single case of motion in such a globular cluster. And still we dare say that there is very little in this world which is more certain than that all these stars are in motion, every one of them continually.

Let us assume that for a moment all the stars in such a globular cluster were at rest. We then can be absolutely sure that in the next moment they all would be in motion.

The Newtonian law demands that all these stars attract each other with a force depending on masses and distances.

Let us take a star in the outer regions in the cluster. If this star for a moment were at rest, it instantly would be caught by the collect-

ive gravity from all the other stars. It is easy to see that this attraction must be directed towards the center of the cluster.

The star begins to move towards the center. The force is acting all the time in the same direction, and consequently the speed of the star must increase without interruption, until the star has passed the center of the cluster. The star runs over to the other side. The force now is acting in the opposite direction to the motion, and the speed decreases, and after a certain length of time the star stops far out on the other side. The force will now bring the star back again. It passes through the center again, and in this way this star—and all other stars—will keep on traveling in orbits out and in, in and out.

In reality the orbits of the different stars will be much more complicated than that. We assumed that the star had been at rest in a given moment. In such a case it would, as we have seen get a radial motion through the center. But in reality the stars, generally, will also have a component of motion vertical to the line through the center of the cluster. How the movements will show themselves in this more general but also more complicated case is a problem which can be mathematically solved.

In Fig. 2 we have an example of motion in globular clusters under the general conditions.

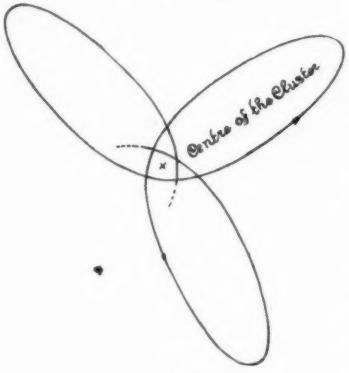


FIGURE 2.

But until now we have neglected an important thing. Until now we have been talking only about the effect of the globular mass *as a whole*. But now and then it will happen that two stars come so close together, that their motions will be entirely altered.

The Newtonian law says: the force of attraction is greater the closer the masses are to each other. Therefore if two stars approach each other closely, their mutual attraction will be so great that it will overcome the attraction of the cluster as a whole, with the result that the orbits of our two stars will be radically changed.

In this connection it is not without interest to note that even in our solar system, in spite of the fact that the masses composing it are so exceedingly small in comparison with one, the sun, movements are found which are quite analogous to the case now alluded to. We have, as a matter of fact, in our solar system examples of comets, the orbits

of which, *because of nearness to one or other of the larger planets* have been entirely changed.

Thus we find the motion of the stars in a globular cluster to be this: in the main all the stars are in a motion governed by the collective attraction of the whole cluster, but once in a while two stars get so close together, that both are thrown out of their normal orbits.

This result is very interesting, because we have here a strange analogy to the motions in an entirely different problem of natural science.

I think that all my auditors have an idea about how the physicist explains the conditions operating in the gases: innumerable molecules, which move around and about in the mass, meet each other and disturb each other's orbits, just as we imagine the motions in a globular cluster.

The motions in such a mass of gases can be subjected to a mathematical investigation, and of the results of such an investigation we will mention the following:

In a globular mass of gas the molecules will ultimately arrange themselves in such a way that the mass will be densest in the center and gradually thinner towards the outer regions.

Exactly as is the case with a globular cluster!

But the theory of gases also claims another result:

In a mass of gas the bigger molecules will by and by acquire low velocities and the smaller molecules high velocities.

Let us think of a cluster! It contains millions of stars of different masses, large and small. After a long time the conditions will be such that the largest stars will have low velocities and the smaller masses high velocities.

Let us think of our Milky Way system! We have there the millions of suns with their planets and satellites and more diffuse masses—the comets. But is there *no* nebulous matter, are there no *comets* in the space *between the different solar systems*?

Now, *Charlier* has made the following suggestion, based upon the theorems as to the theory of gases and the globular clusters which we have now pointed out. The diffuse nebulous masses in the space *between* the different solar systems would be the smallest independent masses in our Milky Way system. Consequently they would in the course of time develop the greatest velocities; as a rule they will attain such great velocities *that they will be simply expelled from the Milky Way system.*

Thus the whole situation would be clear, the diffuse nebulous masses *within the solar systems*, in other words *the comets* would on the

whole be retained each by the gravitation of its own sun, while those traveling in the space *between* the different solar systems would be driven out from the Milky Way system in the course of time.

We will let the matter rest here.

An exact treatment of the orbits of the comets in our solar system, obtained from observations, has yielded the result that the comets of our solar system actually belong to it, and therefore that they have not wandered in from the outside.

This result has now been accepted by probably all astronomers who have acquainted themselves with the problem. But surprisingly enough, it has required a long time for this simple idea which we have discussed to become established.

It is singular that orbits of hundreds of comets were computed without leading the computers to investigate the influence of the perturbations produced on the original cometary orbits, and this in spite of the fact that the significance of the perturbations on the orbits of *planets* had been well understood for two centuries.

It is related of Charles Darwin that once, in replying to an encouraging letter from a friend in respect to the acceptance of his theory as to the origin of species, he replied that although he certainly believed his theory of the development of species would one day win acceptance, he feared it would take as long a time as the development of species itself had taken.

But it was not as bad as that.

And in *our* problem, the simple thought of the necessity of taking into consideration the effect of the perturbations on the orbits of the comets, when one wishes to draw cosmogonic conclusions, has not taken as long a time to become recognized as is required by the comets of *long* periods to make their circuit around the sun. However, those comets which have the *shortest* periods of revolution had to make many circuits about the sun, before the simple idea, which has been the subject of our consideration, really became clear to the calculators of the orbits of comets!

AN AMATEUR ECLIPSE EXPEDITION.

ALFRED RORDAME.

As the eclipse of June 8, 1918 happened in a section of the country easy of access from Salt Lake City, the writer determined to photograph the corona with a lens having a fairly large aperture and short focus, thus doing away with the necessity of clockwork and a heliostat.

As a number of people at this place were anxious to view the total eclipse, an observing party was eventually brought together, consisting of a number of persons interested in astronomy.

The weather conditions in the intermountain states during the first week in June is generally unsettled and in consequence it became desirable to place ourselves in the most favorable situation. According to the reports of the U. S. Weather Bureau the best place ought to be

MR. RORDAME'S ECLIPSE CAMERA.

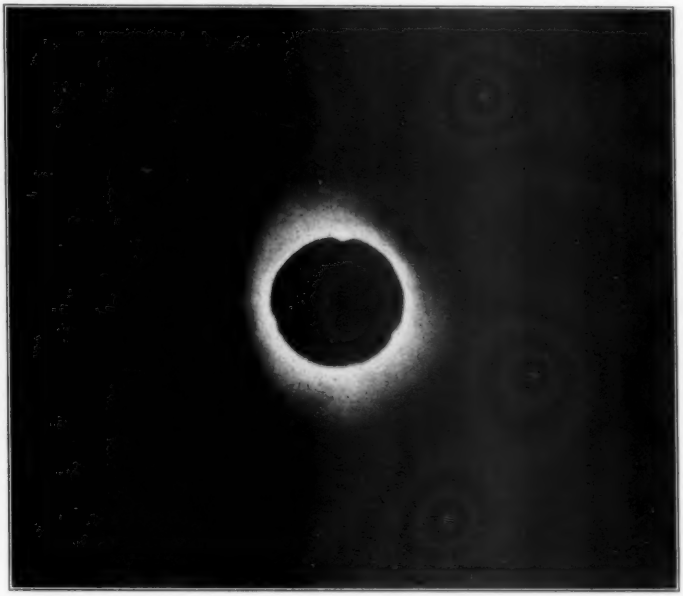
near Green River, Wyoming, and in order to make assurance doubly sure, we decided to travel by automobile, so that we could be more or less independent of weather conditions.

The success of the expedition was due in a great measure to the courtesy of Mr. Theodore Lovendale of this city, who generously placed his high-powered motor-car at our disposal.

Upon our arrival at Green River, June 8 at 11:30 in the forenoon, we selected a station just below and to the west of that of the Yerkes Observatory, which was situated about 100 yards north and below the big butte called Castle Rock. This was a spot somewhat sheltered from the prevailing northerly wind.

The highway at this point turns towards the northwest running for a number of miles directly into the center of the coming shadow, and I therefore determined to have the car in readiness, should the weather become overcast, to make a dash for a place where the sky was clear.

The weather upon our arrival was delightful and clear. The clouds that covered the sky the day before had drifted towards the south. At 2 o'clock in the afternoon, however, the clouds again began to gather in the northwest and drifted across the sky, obscuring the sun at intervals.

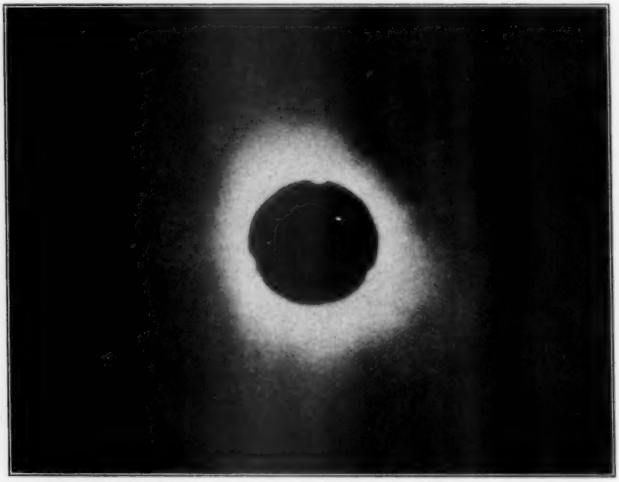


THE CORONA JUNE 8, 1918.
Photographed by Alfred Rordame near Green River, Wyoming.
Exposure one-fifth second. Darlot lens, 2½-inch aperture, 10-inch focus.

At the hour and minute predicted, the sun was cut into towards the west and the black body of the moon slowly advanced, until the solar disc was reduced to the form of a thin crescent and the eclipse neared totality. Seeing that the sun would in all likelihood be covered by the clouds at the critical moment, the writer with the members of the

Lovendale family jumped into the motor-car, a 12-cylinder Cadillac, and raced north-west 3½ miles into a clear sky. The distance was made in about 4 minutes, and no one, not even the ladies, complained of the speed at which we traveled, as we hit the high spots in the road.

It was 10 minutes before totality when we reached our stopping place, a fairly level table land with a clear sweep to the western horizon. The sunlight was now reduced to such a degree that the shadow of every object became sharply defined. The color of the sky became a deep purple, the clouds towards the south taking on a leaden hue and seemingly descending towards the earth. The effect of the illumination was weird and uncanny in the extreme.



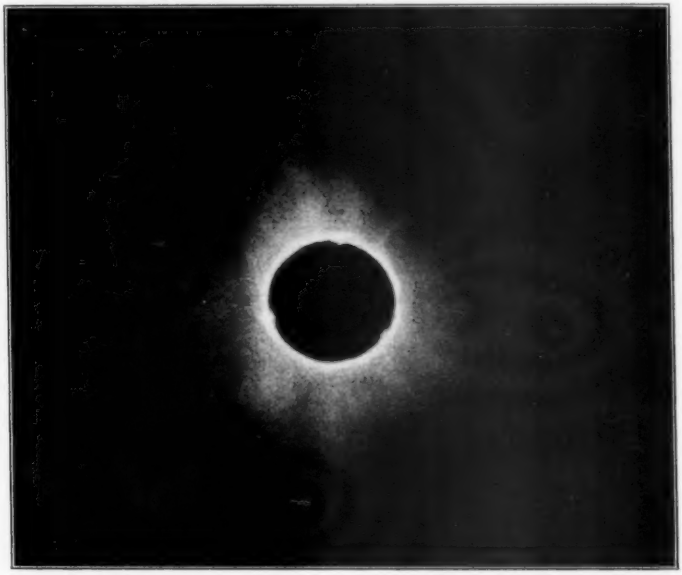
THE CORONA OF JUNE 8, 1918.
Photographed by Alfred Rordame near Green River, Wyoming.
Exposure two-fifths second. Darlot lens, 2½-inch aperture, 10-inch focus.

About 3 minutes before totality the shadow bands appeared like waving banners in the atmosphere, and on noticing the white road, which at this place runs directly north and south, we saw them lying across it, seemingly about 8 inches apart, in a northwest to southeast direction and moving from northeast to southwest.

The shadow of the moon now filled the western horizon and could be seen bodily advancing towards us, making us sensible of the velocity with which the heavenly bodies are moving. The startling rapidity with which the different transformations now took place was amazing.

An instant after noticing the shadow my eyes were again turned towards the sun. With the suddeness of the switching on of an electric light, the planet Jupiter shone radiantly in the sky.

Immediately after the corona became visible, even before the sun was fully covered. The excitement of all now became intense and I found myself in the predicament of Sir Francis Galton, as related in Mabel Loomis Todd's delightful book "Total Eclipses of the Sun", who wholly forgot to notice the times of contact. I had a small telescope



THE CORONA OF JUNE 8, 1918.
Combination of three negatives. Photographed by Alfred Rordame near Green River, Wyoming.

mounted on the camera, intending to examine the prominences, but never once looked through it during totality—my whole attention being given to observing the corona and making the photographic exposures.

It is impossible to put in words the feeling that the sight of the corona produced—a celestial pearly radiance that I had dreamed of for years. One of the desires of my life was a sight of its heavenly beauty, and now that it actually appeared to me, the vision transcended all my anticipations. Photographs, while perhaps giving an idea of the shape and general outline, fail miserably in impressing on us the glory of the spectacle.

The members of the Salt Lake party were all asked to draw the outlines of the corona immediately on the reappearance of the light, and their drawings were handed to me without consulting with one another and without alterations. The result shows that we were fairly unanimous in showing the position of the prominences, but failed in giving the location and direction of the faint extensions in the same place.

THEODORE LOVENDALE.

MRS. J. C. ALTER.

C. W. FREED.

ALFRED RORDAME.

DRAWINGS OF THE CORONA BY MEMBERS OF THE SALT LAKE PARTY.

The next most impressive phenomenon during totality was the band of light at the western horizon where we could see the sun shining beyond the shadow cone. The light was of an orange hue and caused the balance of the clear sky to take on a purplish tinge, while, as stated before, the cloudy portion overhead seemed to descend bodily towards us.

After making four exposures, varying from one-fifth second to three-fifths second, a sheaf of light spurted out with startling suddenness and the corona faded to the land of memories.

The Salt Lake party consisted of J. Cecil Alter, meteorologist, Theodore Lovendale and family, L. C. Moore, C. W. Freed and the writer. Father Rapier, President of All Hallows College, with a number of students of the school, and Dean Gibson of the University of Utah remained at Green River and so missed most of the phenomena.

Salt Lake, Utah.
July 14, 1918.

MATHEMATICS OF THE REFLECTING TELESCOPE.

CHARLES G. RUPERT.

The reflecting telescope makes use of the principle that when light is reflected from a concave mirror the rays converge and form an image of the object observed at the focus of the mirror (Fig. 1).

The curve usually employed for the purpose has been in the past that of the circle, because of the ease with which it may be constructed.

The parabola however, as will be seen, is much superior for the purpose and has been used on many instruments of recent construction.

The Spherical Mirror.

Rays of light coming from an infinite distance and therefore parallel, falling upon the surface of the concave spherical mirror, are reflected to a point located between the mirror and the centre of curvature.

If the curve has a very large radius and only a small section of it be used, the point of convergence is very nearly half way between the mirror and the center of curvature, but as the light strikes farther and farther away from the center, the point of convergence moves toward the mirror as shown in Fig. 2 by the points 1, 2, 3. In each case the distances $1a$, $2b$, $3c$ are equal and only when a approaches closely to x does $1a$ become nearly equal to $1x$ and Fx.

For the purpose of a telescope, therefore, where it is important that all the light from a given point be concentrated at a focus, it is obvious that the spherical mirror can only be used when the radius is very large and when only a small central portion of the glass is utilized. This leads to the inconvenience of making the tube of the telescope excessively long.

This failure of the light from all parts of a spherical mirror to come to a focus is called spherical aberration.

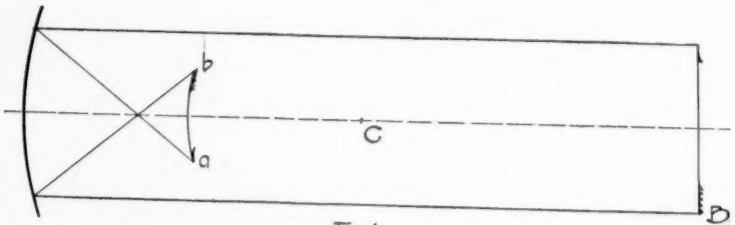


FIG. 1

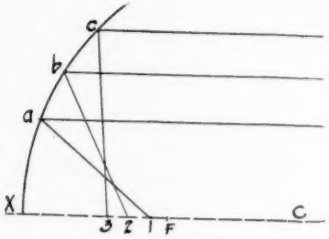


FIG 2

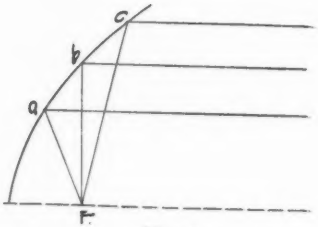


FIG 3

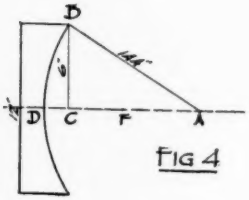


FIG 4

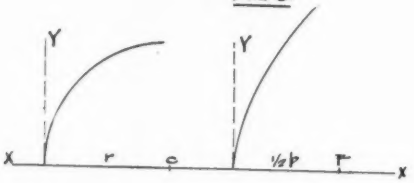


FIG 5

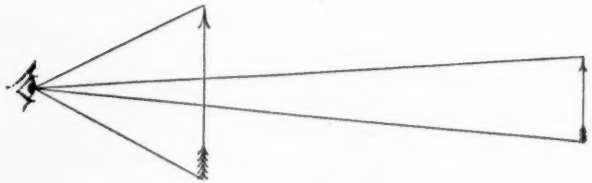


FIG 6

THE PARABOLIC MIRROR.

This curve, while more difficult to construct, has the great advantage over the sphere of concentrating all parallel rays exactly at the focus. Its geometrical properties are such that a line from the focus to any point on the surface and one parallel with the axis make equal angles with the tangent at that point, which is not true in the case of the sphere, with reference to its center (Fig. 3).

The actual difference in the shapes of Spherical and Parabolic mirrors will be seen from the following figures:—

The depression CD of a spherical mirror 12 inches in diameter would be

$$\overline{AB}^2 - \overline{BC}^2 = \overline{AC}^2 \qquad \text{(Fig. 4)}$$

$$20736 - 36 = 20700 \qquad AC = 143.8749$$

$$AD - AC = 144 - 143.8749 = .1251$$

Or this may be derived thus (Fig. 5):

$$y^2 = 2rx - x^2 \qquad r = \text{radius} = 144 \quad y = 6$$

$$y^2 = 288x - x^2$$

$$x^2 - 288x = -36 \qquad \text{Add } 144^2$$

$$x^2 - 288x + 20736 = 20700$$

$$x - 144 = \pm 143.8749 \qquad x = .1251 \text{ (or } 287.8749)$$

In case of the parabola (Fig. 5),

$$y^2 = 2\,px \qquad p = 144 \quad y = 6$$

$$x = \frac{36}{2p} = \frac{36}{288} = .125$$

Thus the difference of x in the circle and the parabola is

$$.1251 - .1250 = .0001 \text{ inch}$$

which means that the glass for a spherical mirror 12 inches in diameter, 72 inches focal length, is worked out 1/10,000 of an inch more than the parabolic.

The relative curvature of the circle and parabola are shown thus:—

Let r = the radius of a circle

" p = twice the distance from the vertex to the focus of a parabola.

Circle	Parabola
$y^2 = 2rx - x^2$	$y^2 = 2px$
$2y\,dy = 2r\,dx - 2x\,dx$	$2y\,dy = 2p\,dx$
$dy = \frac{r}{y}\,dx - \frac{x}{y}\,dx$	$dy = \frac{p}{y}\,dx$
$dy = \left(\frac{r}{y} - \frac{x}{y}\right)dx$	$dy = \frac{144}{y}\,dx$
$dy = \frac{144 - x}{y}\,dx$	
or	or
$dx = \frac{y}{144 - x}\,dy$	$dx = \frac{y}{144}\,dy$

These formulæ indicate that at any point for a given increase in the value of y the increase in the value of x is greater in the circle than in the parabola (as the term $-x$ increases the value of the fraction). Therefore from the vertex the curvature of the circle constantly exceeds that of the parabola.

Focal Length.

The focal length of a telescope is the distance between the center of the mirror and the focus. To avoid excessive length in the instrument a combination of mirrors may reduce this distance while preserving the optical relations of the greater focal length. This is explained later in connection with the convex mirror, and is called equivalent focal length.

Size of the Image.

By magnification in a telescope is meant the increase of the angle subtended by the image over that subtended by the object.

Thus with the naked eye the moon subtends an angle of about 15 minutes. If magnified by 50 the angle would be 750 minutes or 12½ degrees (Fig. 6).

These relations are covered by the formula

$$\frac{\text{Diam. Image}}{\text{Diam. Object}} = \frac{\text{Distance of Image}}{\text{Distance of Object}}.$$

Therefore, calling the distance of the image the Focal Length,

$$\text{Diam. Image} = \frac{\text{Diam. Object} \times \text{Focal Length}}{\text{Distance of object}}.$$

In the case of the Moon the diameter equals 2000 miles and its distance is 240,000 miles. With a mirror of 6 ft. focal length

$$\text{Diam. Image} = \frac{2000 \times 5280 \times 6}{240{,}000 \times 5280} = \frac{1}{20}\text{ ft.} = .6\text{ in.}$$

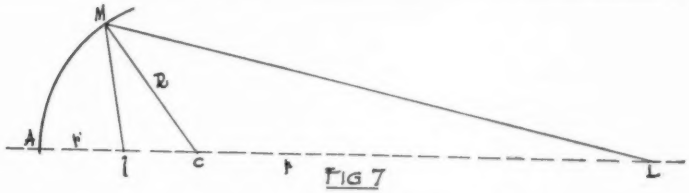


FIG 7

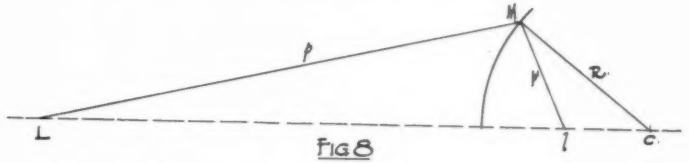


FIG 8

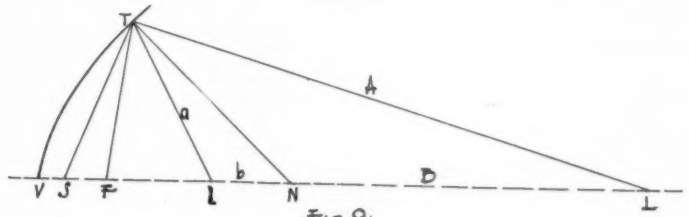


FIG 9

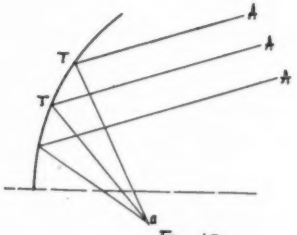


FIG 10

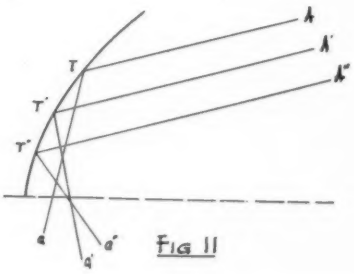


FIG 11

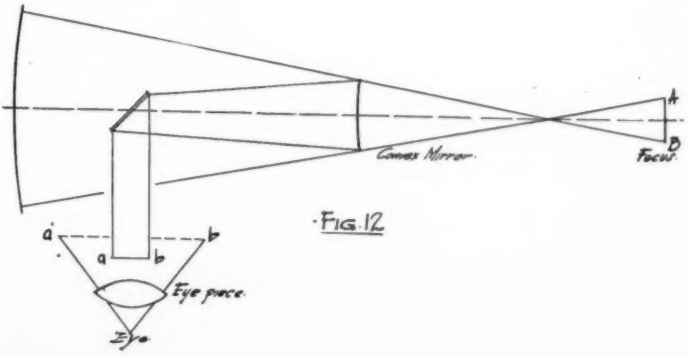


FIG 12

It will be observed that the diameter of the image varies directly as the focal length, directly as the diameter of the object, and inversely as the distance of the object; and therefore the image presented will vary according to these conditions.

It is seen that for each foot of focal length the diameter of the moon's image varies 1/10 of an inch. Thus in a telescope of—

6	ft. F.L.	the image has a diameter of	.6 inch
20	" "	" " " " "	2. "
15 inches	" "	" " " " "	.125 "

These are the actual sizes of the images that are presented at the focus and which are then magnified by the several eyepieces as described later.

Magnification.

The image of the Moon 2 inches in diameter, if observed from a distance of 20 feet, would subtend the same angle as does the Moon itself from a distance of 240,000 miles. If viewed from a distance of 1 foot it would appear 20 times as large.

If the image is placed at the focus of an eyepiece, the observer's distance is more accurately fixed and the magnification will be determined by the relative focal distances as explained under eyepieces subject however to some variations in the observer's eyes.

Formulæ for Concave Spherical Mirrors.

(See Fig. 7.)

Let R = Radius of curvature = MC which is a normal.

Light from L is reflected to l making equal angles with this radius.

Let

$$p = LA, \qquad p' = lA$$

then, from the similarity of the triangles.

$$\frac{Cl}{CL} = \frac{lM}{LM}.$$

When the arc is small

$$ML = AL = p,$$
$$Ml = Al = p',$$

$$Cl = CA - Al = R - p',$$
$$CL = AL - AC = p - R,$$

Substituting in formula (1) gives

$$(R - p')\, p = (p - R)\, p'.$$

Reducing

$$\frac{1}{p} + \frac{1}{p'} = \frac{2}{R}, \qquad p' = \frac{R}{2 - \frac{R}{p}}.$$

When p is infinite

$$p' = \frac{R}{2},$$

that is, the image is formed at the focus l.

When $p = R$, $p' = R$.

" p is at focus, p' is at an infinite distance.

FORMULÆ FOR CONVEXED SPHERICAL MIRROR.

(See Fig. 8.)

$$\frac{1}{p'} - \frac{1}{p} = \frac{2}{R}$$

$$R = \frac{2pp'}{p - p'}$$

The image is on the opposite side at l.

FORMULAE FOR LIGHT REFLECTED BY A PARABOLIC MIRROR..

(See Fig. 9.)

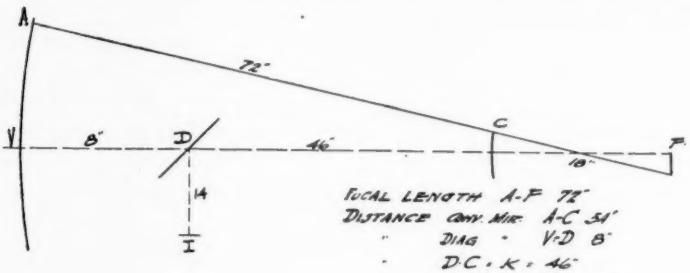
Light from any point on the axis VL falling upon the mirror at T is reflected to l, making equal angles with the normal TN. This normal therefore bisects the vertical angle of the triangle lTL.

Therefore the sides bear the relations

$$\frac{a}{b} = \frac{A}{B}, \qquad b = \frac{aB}{A}.$$

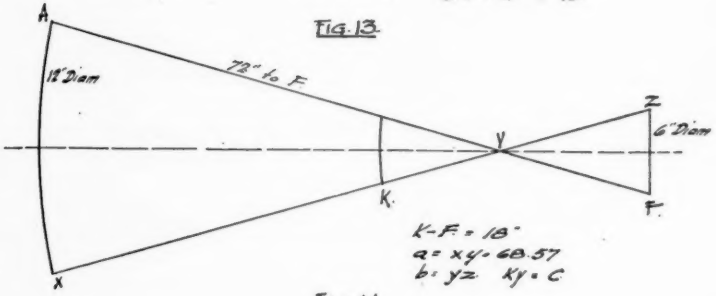
1. When $B = 0$, $b = 0$; the points L and l will coincide with N. The light falling upon T will be reflected back to N. That falling between T and V will be reflected to points on the axis between F and N, and that falling upon the mirror beyond T will be reflected to points on the axis to the right of N.

2. When $B = A$, then $b = a$. In this case the point L is at an infinite distance and the rays of light coming from it come parallel with the axis VL and are reflected to a point on the axis at a distance a from the base of the normal. There is but one point on the axis that meets these conditions and that is the principal focus of the parabola F, which is equally distant from both ends of a normal. Therefore all rays of light coming from an infinite distance parallel with the principal axis converge at the focus F. These] are the conditions when a telescope is receiving light from a star.



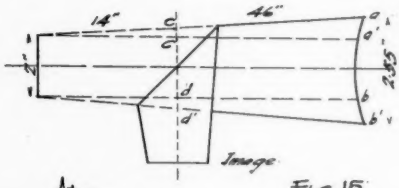
FOCAL LENGTH A-F 72"
DISTANCE CONV. MIR. A-C 54"
" DIAG " V-D 8"
" D-C = K = 46"
" D to IMAGE I = x = 14"
" K+x = a = 60"
" C-F = a' = 18"

FIG. 13.



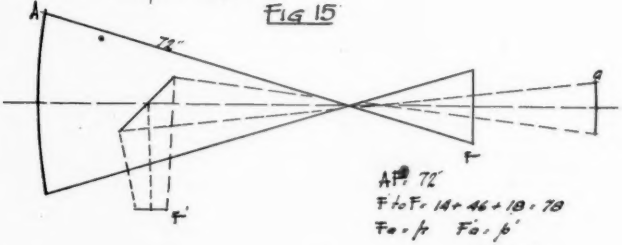
K-F = 18"
a = xy = 68.57
b = yz Ky = c

FIG 14



aa'+bb' = 2.55-2 = .55
cc'+dd' = x.
x+2 = Diam of the pencil of Rays of this point

FIG 15



AF = 72"
F to F = 14+46+18 = 78
Fa = f Fa' = f'

FIG 16.

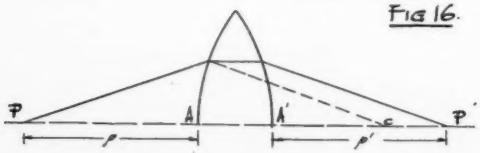


FIG. 17.

It will be noted that the size of the parabolic mirror in no way alters these conditions as was the case with a spherical mirror and in this fact lies the superiority of the parabolic mirror for large telescopes.

3. When B has any value between 0 and infinity, that is, when it lies on the principal axis beyond N,

$$b = x\frac{a}{A}.$$

Therefore b will have a value greater than 0 and less than a, and the light will be reflected to a point on the axis between F and N.

4. When L is located between F and N the conditions of 3 are reversed. This arrangement applies to the second concave mirror used on the Gregorian Telescopes (which see later).

We have considered only cases where the origin of light is upon the principal axis. When the origin is at A (Fig. 10) instead of L the rays strike the mirror at T and are reflected making equal angles with the normals at these points and converge on the axis A at the point a with a spherical mirror.

With a parabolic mirror however this is not true. Rays of light which come at an angle with the axis of the parabolic do not converge to a common point (Fig. 11).

The nearer the point of contact T is to the principal axis the more nearly do the conditions approach to those of the spherical mirror. But in no case does the parabolic mirror focus clearly rays of light unless their source lies upon the axis of the mirror (Fig. 3). It is therefore important that the axis of the mirror of a parabolic reflecting telescope be accurately in line with the axis of the instrument.

Kinds of Reflectors.

There are various possible arrangements of the mirrors in reflecting telescopes.

The two which are principally used are the Cassegrain and the Gregorian.

In the former the light after being reflected by the first mirror is returned to the eyepiece by a convex mirror (Fig. 12) and in the latter by a concave mirror (Fig. 16).

The Cassegrain Telescope.

The arrangement of the mirrors is shown in Fig. 12 and the dimensions in Fig. 13.

With these distances, which are chosen arbitrarily for convenience of construction, the amount that the convex mirror will increase the

object is found by the proportion existing between the distance of the object and the distance of the image from the convex mirror.

$$\frac{p}{p'} = \frac{a}{a'} = \frac{60}{18} = 3\tfrac{1}{3}$$

As it has already been shown the image of the moon in an instrument with the above dimensions, at the focus of the concave mirror is .6 inch diameter it is now increased $3\frac{1}{3}$ times and is 2 inches in diameter at the focus of the convex mirror.

The focal length of the parabolic mirror in this instrument is 6 feet. This now multiplied by $3\frac{1}{3}$ gives the total equivalent focal length of the instrument = 20 feet.

Convex Mirror.

The radius of curvature of the convex mirror to produce this result is found by the formula

$$RC = \frac{2aa'}{a - a'} = 51.42 \text{ inches} \qquad \text{(See Fig. 13.)}$$

It has been assumed that the convexed mirror is spherical. In such a mirror the rays of light converging toward the focus are reflected to a point only approximately, when a small section with a large radius of curvature is used, but never exactly (Fig. 24).

To get good definition a hyperbolic mirror must be used, which reflects all rays directed toward one focus exactly to the other focus of the hyperbola (Fig. 25).

Diameter of Convex Mirror.

The diameter of the convex mirror sufficiently large to cover the moon's image would be found as follows (Fig. 14).

The point p where the rays from the extreme edges cross is found by the proportion

$$\frac{12}{.6} = \frac{a}{b}; \qquad \text{when } a + b = 72 \text{ inches}, \quad b = 3.43, \quad a = 68.57, \quad c = 14.57$$

The minimum diameter of the convex mirror is therefore

$$D = \frac{12 \times 14.57}{68.57} = 2.55 \text{ inches.}$$

The actual size of the mirror may be, say, $3\frac{7}{16}$ diameter with 1/16 covered by the cell, leaving $3\frac{5}{16}$ clear aperture. The total diameter of the cell is $3\frac{1}{2}$ inches and it therefore obstructs $8\frac{1}{2}\%$ of the light coming to the 12-inch mirror.

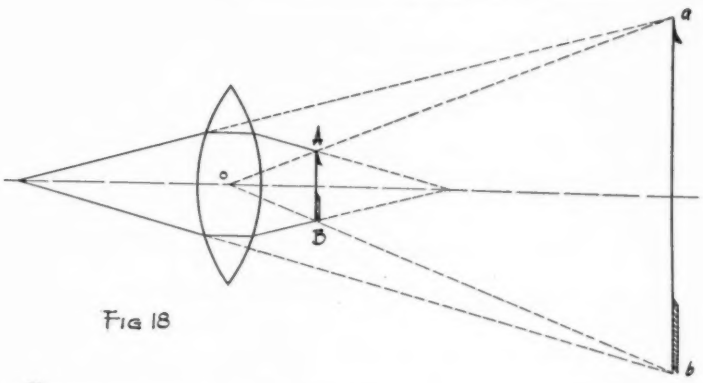


FIG 18

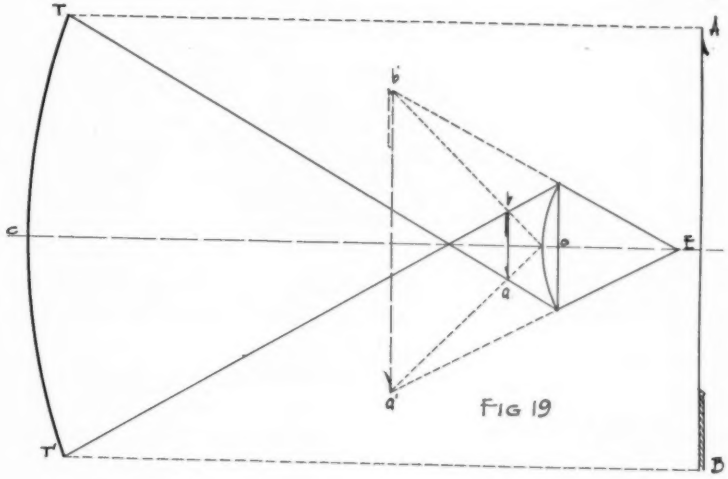


FIG 19

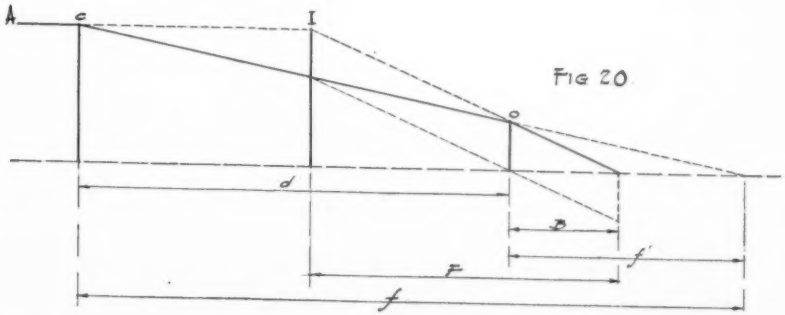


FIG 20

Diameter of Diagonal Mirror.

The diameter of the diagonal mirror is found as follows (Fig. 15):

$$\text{Diam. } 2.55 - 2 = .55 \qquad \frac{x}{.55} = \frac{14}{46} \qquad x = \frac{77}{46} = .167$$

$$.167 + 2 = 2.167 = \text{Diameter.}$$

Flat Secondary Mirrors.

If it were desired to use a mirror that would not magnify the image but would present it at $A'B'$ of the same size that it was at AB (Fig. 13), it must fulfil the conditions

$$\frac{a}{a'} = 1, \qquad a = a'.$$

Keeping $x = 14$ and keeping the same position of the diagonal, which is 8 inches from the large mirror,

$$K + 14 = a \qquad K + a' = 64 \qquad a' = 64 - K$$

$$K + 14 = 64 - K$$

$$2K = 50 \qquad K = 25$$

$$a' = 64 - 25 = 39.$$

Therefore the mirror should be placed $25 + 8 = 33$ inches from the large mirror, instead of 54 inches, and its radius of curvature would be

$$\frac{2aa'}{a - a'} = \frac{2 \times 39 \times 39}{0} = \text{infinity},$$

that is, it would be a flat mirror.

Its diameter would be (Fig. 12)

$$C = 68.57 - 33 = 35.57$$

$$D = \frac{12 \times 35.57}{68.57} = 6.2 \text{ inches},$$

Gregorian Type of Telescope.

(See Fig. 16).

In this instrument a second concave mirror is used in place of the convex of the Cassegrain and is placed beyond the principal focus F, of the first mirror.

The first image, formed at F, is then the object for the second mirror and is reflected to F'.

To get $F' = 3\frac{1}{3}$ times F, as in our instrument, would necessitate making

$$\frac{p'}{p} = \frac{10}{3} \qquad 10\,p = 3\,p' \qquad p' = 78 + p$$

$$10\,p = 234 + 3\,p$$

$$7\,p = 234, \qquad p = 33.42, \qquad p' = 111.42.$$

The second mirror would then be placed $72 + 33.42$ inches from the first $= 105+$ inches, as against 54 inches in the Cassegrain.

The radius of curvature of this *concave* mirror would be

$$R = \frac{2pp'}{p+p'} = \frac{2\times 33.42\times 111.42}{144.84} = 51.42.$$

The object F' therefore is located 17.86 inches within the centre of curvature or foot of the normal. As the object is inverted twice, once by each concave mirror, it is finally presented in an upright position in a Gregorian Telescope.

The Eyepiece.

The eyepiece is a lens, or combination of lenses, with which to view and magnify the image made by the mirrors.

The simplest form of eyepiece is a double convex lens.

If both sides are curved alike, the focus F corresponds very nearly with the centre of curvature, but this condition varies according to the index of refraction of the glass from which it is made and also with the diameter and thickness of the lens.

An excessive diameter produces spherical aberration, in that the rays of light passing through the outer parts of the lens converge to a point nearer the lens than do those passing near the center of the lens.

This difficulty may in a measure be overcome by giving the two foci of the lens different radii of curvature. It may also be modified by using two lenses of greater focal length placed a little apart, as in the Huyghens or negative eyepiece.

Formulae for Lenses.

(See Fig. 17).

Let $N =$ the refractive index of the lens.

" $CA' = R$ and $C'A = R'$.

It may be shown that for a double convex lens

$$(n-1)\left(\frac{1}{R} + \frac{1}{R'}\right) = \frac{1}{p} + \frac{1}{p'}$$

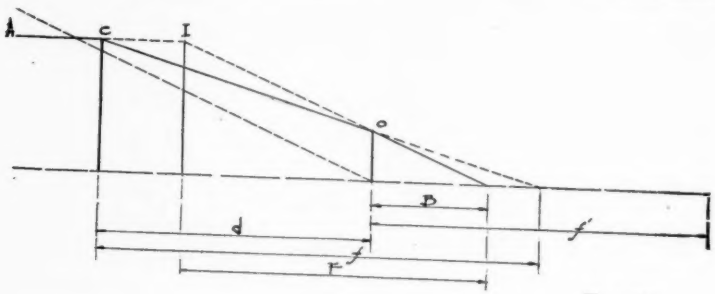


FIG 22

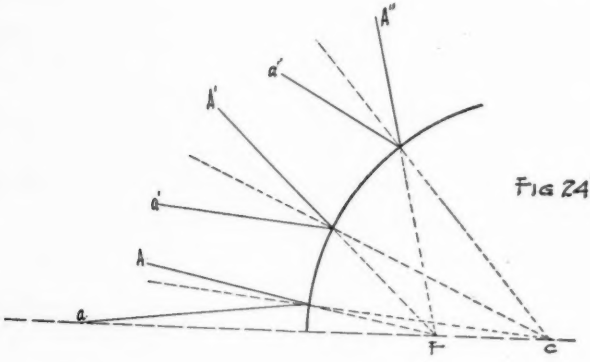


FIG 24

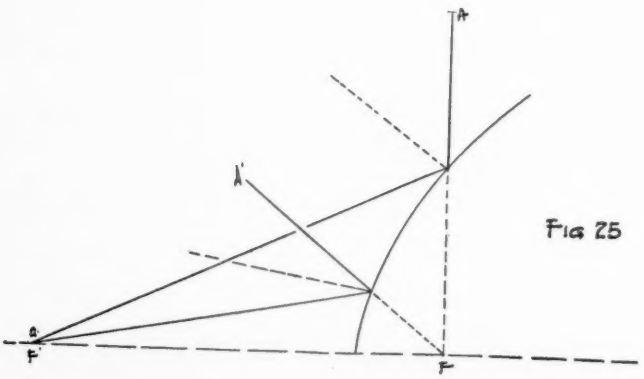


FIG 25

If p = infinity, that is, if the rays are parallel to the axis,

$$(n-1)\left(\frac{1}{R}+\frac{1}{R'}\right)=\frac{1}{p'};$$

p' then is the principal focus.

Calling $p' = f$, we get

$$(n-1)\left(\frac{1}{R}+\frac{1}{R'}\right)=\frac{1}{f}.$$

Combining the first and third equations we get

$$(1)\quad \frac{1}{p}+\frac{1}{p'}=\frac{1}{f}, \qquad p'=\frac{fp}{p-f}.$$

When the image is virtual, which it would be when p is inside of C, the formula becomes

$$(2)\quad \frac{1}{p}-\frac{1}{p'}=\frac{1}{f}.$$

For double concave lenses the formula is

$$(3)\quad \frac{1}{p}-\frac{1}{p'}=-\frac{1}{f}$$

Knowing then the focal length f of a lens, the position of the image p' may be found for any value of p. In formula (1)

If p = infinity then $p' = f$ and the image is at the principal focus.

If $p < f$ then $p' < 0$, p' has a negative sign and the image is virtual.

If $p > f$ then $p' > 0$ and the image is real.

Combination of Lenses

If parallel rays fall upon a convex lens with focal distance f and then upon another with focal distance f', the distance between the lenses being d, then

$$F=\frac{ff'}{f+f'-d},$$

in which F is the focal length of the combination. When the two lenses are close together $d = 0$, and the formula becomes

$$F=\frac{ff'}{f+f'},$$

If the two lenses have the same curvature, then

$$f = f' \text{ and } F = 1/2\, f,$$

that is, the focal distance of the combination is half that of a single lens.

The Huyghens Eyepiece.

The Huygens or Negative Eyepiece consists of two convexed lenses arranged as in Figure 20. C is called the field lens and O the eye lens.

There are three particular advantages in this arrangement:

1. By using lenses with large radii of curvature the spherical aberration is reduced.

2. The field of view is enlarged. This is made apparent if we imagine the lens C to be removed. Then to get the same magnification the eye lens would be of less focal length and would be moved so close to $A\ B$ that it could not cover as much of the object or in other words the field of view would be reduced.

3. Chromatic aberration is entirely overcome.

Light refracted by a lens is separated into its prismatic colors. The focal length for the red rays is greater than for the violet and these would fall after passing through the lens C at the points r and v respectively, thus forming a series of images of different colors. But the eye lens is placed so that its focus for the red rays is at r and its focus for the violet rays is at v, in consequence of which these colors are brought together again and after passing through the eye lens are united.

The relations existing between the lenses in a Huyghens eyepiece are such that—

The field lens has a focal length three times that of the eye lens $f = 3f'$ and the distance between them $d = 1/2\ (f + f')$.

The formula for combinations of lenses is

$$F = \frac{ff'}{f+f'-d}.$$

Substituting the above values this reduces to $F = 1/2\ f$.

The focal length of a Huyghens eyepiece equals half the focal length of the field lens.

An eyepiece therefore of 4.8 inches focal length would have a field lens of 9.6 inches focal length, an eye lens of 3.2 inches focal length, and the lenses would be $1/2\ (f + f') = 6.4$ inches apart.

The Ramsden Eyepiece.

The Ramsden or positive eyepiece has two lenses as in Figure 22. They are of equal focal length $f = f'$ placed at a distance from each other of 2/3 the focal length of one.

$$d = 2/3\ f$$

Substituting these values in the formula

$$F = \frac{ff'}{f+f'-d},$$

$$F = 3/4\, f.$$

The focal length of the combination is therefore 3/4 the focal length of either lens.

The Kilner Eyepiece.

The Kilner eyepiece is a modification of a Ramsden.

$$F = \frac{ff'}{f+f'-d} = \frac{47 \times 32.8}{47+32.8-18} = 24+ \text{ mm} = \text{about 1 in.}$$

Focal Point of Combination.

The focal point of the combination of lenses is located beyond the eye lens at a distance

$$B = \frac{f'(f-d)}{f'+f-d}.$$

In the Huyghens (Fig. 20) $B = \frac{f}{6}$.

In the Ramsden (Fig. 22) $B = \frac{f}{4}$.

Magnification by the Lens.

The relative magnitudes of the object and image formed by a lens are in proportion to their respective distances from the lens (Fig. 18).

In the triangles AOB and aOb,

$$\begin{array}{ll} \text{The Object} & \frac{O}{I} = \frac{AB}{ab} = \frac{OA}{oa} = \frac{p}{p'} = \text{Distance of Object} \\ \text{The Image} & \qquad\qquad\qquad\qquad\qquad\quad = \quad\text{“}\quad\text{“ Image} \end{array}$$

$$\frac{O}{I} = \frac{p}{p'}.$$

Inasmuch as in the use of the eyepiece the object is always at the focus, $p = f =$ focal length.

Substituting,

$$\frac{O}{I} = \frac{f}{p'}, \qquad I = \frac{Op'}{f}.$$

Thus the size of the image varies directly as the focal length. Decrease the focal length or radius which increases the curvature of the lens and the image is increased.

Therefore in comparing one eyepiece with another, one of 1-inch focal length will magnify twice as much as one with 2 inches focal length.

This formula for magnification, while correct enough for all practical purposes, is not strictly accurate for the three following reasons:—

1. The image *ab*, while exactly at the focus of the parabolic mirror (its object being at an infinite distance) is not exactly at the focus of the eyepiece (Fig. 19).

2. The observer's eye cannot be located at *o* but is at some distance toward *E* (Fig. 19), thus making the magnification smaller as the angle $b'Ea'$ is smaller than $b'oa'$.

3. Different observers in order to obtain distinct vision require different adjustments of the eyepiece, thus moving the lens *O* nearer to or farther from the image *ab*.

Magnification in the Telescope.

In Figure 19 is shown the reflection and refraction of the light in a reflecting telescope and a simple eyepiece.

For convenience of demonstrating, the eyepiece and the observer are supposed to be located on the principal axis of the mirror. The image *ab* is at the focus of the mirror and also at or very near the focus of the eyepiece.

Light from the image *ab* is refracted by the lens and as it enters the eye at *E* it comes in the lines $a'E$ and $b'E$ and the image seen is that at $a'b'$ and is inverted.

The relative sizes of the object *AB* and $a'b'$ are in proportion to the angles which they subtend.

It has been pointed out that the image *ab* formed by a mirror, if viewed from a distance equal to the focal length of the mirror, would subtend the same angle as the object itself.

Now if the observer's eye were placed exactly at *O* this same image *ab* would subtend the angle $a'ob'$ and the relative magnitudes of the two objects would be $\frac{CF}{OF}$, where *CF* is the focal length of the telescope and *OF* the focal length of the eyepiece.

The magnification therefore of a reflecting telescope is expressed in terms of the focal length of the mirrors divided by the focal length of the eyepiece.

Thus in an instrument with equivalent focal length of 20 feet or 240 inches, with an eyepiece of 2.4 inches focal length, the magnification is 100.

NEBULAR EVOLUTION.

F. J. B. CORDEIRO.

Continued from page 447.

This must be an old nebula, as its development is nearly finished. The spiral in triangulum is a rather confused mass, as nearly all of the central matter has been thrown out into the arms and the central nucleus exercises less control than the matter in the arms.

We shall now take up the history of a nebula after extrusion has ceased. As we have said, the further development might be simply the contraction of the central nucleus into a central sun. In this connection it will be instructive to examine two nebulas, M64 of Coma Berenices (Plate XXI), and a spiral in Ursa Major, an excellent photograph of which may be found in Garrett P. Serviss' book, "Curiosities of the Sky," p. 97. In the former the arms have developed no knots, but seem to be still a mere swarm of meteorites. Of course, they may contain dark bodies. But the important thing is that the central lens-shaped body is evidently detaching a ring, and this ring is clearly and unmistakably a Laplacian ring. The same thing can be distinctly seen in the second nebula (Ursa Major). The observational evidence is positive that these two nebulas are casting rings. Here we can see a Laplacian evolution actually taking place.

In a textbook of Astronomy I find the following objections to Laplace's conjecture. "The throwing off of the rings is in itself a hypothesis difficult of acceptance, on account of the presumably extreme rarity of the outer parts of the solar nebula and consequent lack of cohesion. Why was the process of expelling rings intermittent instead of continuous? The inner satellite of Mars and the inner edge of Saturn's ring revolve faster than Mars or Saturn. That settles it."

We may say that the detachment of masses may be continuous or not, that depending upon the conditions. In the evolution of our system, it is certain that the original nebula threw out arms from which the four outer planets were formed. The proof of this is that all these planets originally had a negative rotation. This is proved by the fact that the outermost satellites of Saturn and Jupiter still preserve this negative motion. But we shall return to this subject later.

Inside of Jupiter we find a swarm of asteroids. These were possibly detached piece-meal, not necessarily as rings, though that is possible, but perhaps as mere disjointed masses of matter. It is probable that only those above a certain size are spheres. Or they may represent merely the remnants of the stumps of the arms after these had begun

to consolidate into the four giant planets. Or possibly a considerable ring was thrown off, but was prevented from consolidating into a single planet by the disturbing action of Jupiter, as has often been suggested. In a preliminary paper like the present one it is impossible to go into every dynamical detail exhaustively, but it can be shown that a body revolving about a disc of matter in any plane will eventually have its orbital plane brought into coincidence with the plane of the disc and that the final orbit will be a perfect circle having a radius considerably less than the mean distance in the original orbit. And a spheroidal planet attracts exactly like a disk of homogeneous matter. The objections of our author to Laplace's surmise do not disprove it, but rather confirm it.

But to return to the case represented in Plate XXI, where a considerable ring is seen splitting off. We shall first state a dynamical principle. A homogeneous sphere of matter has a maximum attraction at its surface. Inside the sphere the attraction is proportional to the radius, and outside the sphere it is inversely as the square of the distance from the center. But if the density of its matter increases progressively from the surface to the center, the level of maximum attraction is not at the surface but within it. Thus in the case of the earth the level of maximum attraction is about 240 miles below the surface.*

Likewise in a lenticular body progressively denser towards the center the level of maximum attraction is not at the edge, but at some level, AA′, within the edge. In Figure 2 the line CB′ represents the centri-

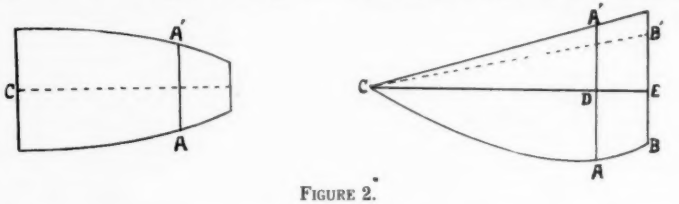


FIGURE 2.

fugal forces, which are proportional to the distance from the center. CAB represents the gravitational curve which is a maximum at D. Let us suppose that as the lens contracts a condition has been reached where EB′ = EB, or the attractional and centrifugal forces at the edge are equal. The attractional forces at all inside points are evidently

* Sir George Airy once measured the force of gravity in a deep mine and was surprised to find that it was greater than at the surface. He had expected that it would be less, on the ground that the shell above him could exert no attraction. He explained it by supposing that there were local condensations of matter in the vicinity.

PLATE XXI

THE SPIRAL NEBULA M64, COMAE BERENICES

N. G. C. 4826 α (1900) $12^h\ 51^m\ 49^s$ $\delta + 22^\circ\ 13'.9$

From a negative taken with the Crossley Reflector at the Lick Observatory.

greater than the centrifugal forces and the mass must keep together. As the lens contracts the centrifugal forces will increase and so also will the attractional forces, so that by the help of the slight cohesional forces, the mass will not split. But eventually we shall have a condition where DA = DA′, the line CA′ representing the increased centrifugal forces. In this condition, the attractional forces are everywhere greater than the centrifugal force to the left of the line AA′, but to the right of this line the centrifugal forces are everywhere greater. Hence AA′ is a line of cleavage and a ring of considerable width will split off at this level. As the central mass contracts, the process will be repeated again and again. There is finally a stage where no further splitting off is possible and the central mass contracts into itself. This was probably the history of the four inner planets, or their evolution was Laplacian. It is therefore certain that there are at least two kinds of nebular evolution—a spiral evolution and a Laplacian evolution, and these may occur separately or together in the same nebula. The four outer planets of our system undoubtedly underwent a spiral evolution, while it seems likely that the four inner planets underwent a Laplacian evolution.

A Laplacian ring has a positive rotation and when it condenses into a single body, that body likewise must have a positive rotation. As its moment of momentum will at first tend to remain constant, its rotational velocity will at first increase with its condensation, but eventually the tidal couple will bring the rotational and revolutional velocities into coincidence, as was the case with the original ring. But whether the planets are rotating positively or not, the total moment of momentum of the system remains constant at all times.

Finally, through gyroscopic principles* the tidal couple, which is always positive and has its axis perpendicular to the invariable plane, will eventually bring the axes of the planets into coincidence with its own axis, both in direction and sense of rotation. That is, eventually the axes of all the planets will become perpendicular to the invariable plane and their rotations will all be positive. The oblateness of the planets holds the orbits of their nearer satellites in their equatorial planes, almost the same as if they were rigidly connected, so that when the tidal couple turns the axis of a planet over, the orbits follow. But when the satellites are very remote this hold of the equatorial protuberance becomes weak. There is always a contest between the equatorial mass and the sun, the former striving to keep the orbit in its plane, while the latter strives to keep it in the planet's orbit. Taking the case of the outermost satellite of Saturn (Phoebe), owing to its

* "Principles of Natural Philosophy." The Author.

extreme remoteness from the planet, the sun has held it, so that although undoubtedly Saturn and all its satellites (as also Jupiter and its satellites) originally moved negatively or upside down, when the tidal couple of the sun turned them over, Phoebe was unable to follow her companions. Uranus and Neptune are now turning over and carrying their satellites with them. We can therefore confidently predict that if ever any other remote satellites of the four outer planets shall be discovered, they will be found to move negatively. The proof that the evolution of these planets was spiral is the remains of the former negative motion which we find in the outermost satellites.

We may remark in closing that the collision of two bodies, or the disruptive effects of a near approach, cannot result in the formation of a spiral nebula, or of a genuine nebula of any kind. There will of course be shattering effects and the production of much heat, but the subsidence of such a catastrophe must be nearly as rapid as its development and it would be dynamically impossible to have any regular form like a spiral as the result of an explosion. Actual nebular evolution always begins at the beginning with the formation first of the lightest gases, such as hydrogen, helium and substances like Nebulium, with their progressive condensation into denser and denser material, while the results of an explosion would be matter mostly in an advanced condition. There is a popular idea that matter is always going through a ceaseless cycle. It is supposed to evolve from a nebula and then two portions dash together and presto it is a nebula again. All the long evolution of ages is undone in a minute and it is back again to its original condition. Nebulas are not formed in this way. The evidence rather points the other way, viz., that they are evolved in situ from the ether, and that they never revert to the ether again or to their original primitive condition. Evolution as we know it, therefore, may be simply part of a general stepping up of matter from lower and primitive forms to higher forms.

In these huge celestial transformations we seem to have prototypes of evolution in general, which are endlessly repeated in minor and more specialized forms. The parent masses have a tendency to reproduce themselves, giving birth to other individuals possessing all the characteristics of the former. Two general forms of reproduction seem to be portrayed here—that by simple fission and that by the more complicated spiral form, which we observe in the heavens and on the seashore. In both forms there is exhibited the ability of a body to reproduce itself through successive generations.

The analogy to organic evolution is perhaps not altogether fanciful. We have the same budding out and shoots from the parent mass, with the subsequent development of the flowers on the branches. These

flowers in due time ripen into the fruit which in its maturity drops away. A new individual has been born, which, in turn, by identical processes, can give birth to other bodies.

109 Warren St.
Newton Center, Mass.
March 27, 1918.

CHAINS WHICH ARE INVISIBLE.

CHARLES NEVERS HOLMES.

Our own Solar System—countless solar systems situated from us at a remoteness of countless miles—is firmly bound together by mighty though invisible chains. These invisible chains are very elastic but none the less unbreakable, that is, they cannot be broken as long as they bind us. Some convulsion of cosmic collision may unshackle us from a few of these mighty chains but our solar system would, in all probability, presently readjust itself to the influence of other invisible chains. Our Solar System might be altered in its form and general appearance but, after such a terrific collision was over, each of its planets and satellites would again be bound by these chains. Although Earth, Moon, Mars, Venus, Mercury and even Jupiter were wholly swallowed up by some invading gigantic sun and its vast system, Saturn, Uranus and Neptune might survive, chained to this gigantic sun, Saturn perhaps revolving like a satellite around a huge planet which had accompanied the intruding sun.

These chains are entirely invisible to our eyes as they are constituted at present, but were our eyes organized differently or were they to develop into different organs in the future, we might be able to see very clearly these chains which are invisible under present conditions. But although we cannot see them directly, we are able to see them indirectly. That is, we can see the terrestrial and celestial effect of these chains, and indeed feel their effect upon our own bodies. Whether or not our own Sun is bound by them to some vast unilluminated body—Neptune indicating as yet no evidence of such a body's influence—is very conjectural, but there is not the slightest doubt that our Earth is bound by them to our Sun. And there is not the slightest doubt that our whole solar system is bound together by them, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and their moons revolving around and around their common sun, each in a "year" which

varies according to the length of orbit and orbital velocity. Were this "law" of our Cosmos to be annihilated, this balance in space to cease, the question arises what would then happen to our little planet-home? The chains that tied it to its sun would be broken, the bonds that drew it towards its fellow planets, would no longer exist, yet terrestrial motion would continue. In all probability, forsaking the "habit" of ages, each solar satellite would assert at once its cosmic independence. Our earth would "fly away" from the sun, our moon would "fly away" from the earth, and if the invisible chains *inside* our planet were annihilated at the same time our earth would "fly away" from itself—from its own center.

Of course if the invisible chains outside our earth were all to be broken, those which are inside our earth would also be broken, for what is popularly known as "gravity" is universal. If the invisible chains which hold the Cosmos together—at least that portion of it called our Universe—were not universal and alike, the *Cosmos* would be the *Chaos*. Some common equalizing and equilibrating force was necessary to develop the Cosmos out of the Chaos and to keep the Cosmos from lapsing back into Chaos. What the stupendous universal force really is we do not know, any more than we know what the Ether really is. Is the lodestone with its invisible chains of attraction a very close kin to it and is universal gravitation merely another expression of universal magnetism? Our sun certainly resembles a terrestrial magnet in that it attracts the earth towards it, and since its volume approximates 1,300,000 times that of our world its power of attraction must be tremendous. Upon the sun as upon the earth these invisible chains of gravity pull all exterior atoms towards the solar or the terrestrial center, and this attraction towards the center of bodies varies directly in intensity according to their size provided such bodies possess exactly the same density. Yet a mean distance of about 93,000,000 miles seems quite a space for our sun to hold us in captivity, particularly since we are revolving around him at an average velocity of more than 18 miles per second. But, nevertheless, we are securely chained to him, as indeed is Neptune, about 2,800,000,000 miles distant from him. Each of us knows how more or less powerfully the invisible terrestrial chains drag him towards the ground—his "weight", and, of course, each of us would weigh a great deal more were it possible to be weighed at the solar surface. There a terrestrial weight of 150 pounds would be increased to a solar weight of about two tons!

It is, however, to be considered that while our sun is pulling upon us, we are also pulling upon the sun. Thus, there exists a reciprocal attraction between sun and earth, although our terrestrial chains pull very feebly compared with the solar chains. There is this same recip-

rocal attraction throughout our entire Solar System, as, for example, between earth and moon and between other planets and their satellites. But it seems more natural that our earth should hold the moon in captivity than that the sun should hold our world, because the moon is comparatively close to us. It is true that the sun and the moon appear to be of about the same size in the firmament, but, nevertheless, the latter possesses only about 1/49th of our earth's volume. However, since the sun is so much farther away, the gravitational influence of our moon is greater than that of the sun. This gravitational influence —an influence which in all probability pervades the entire Cosmos, a cosmos that seems to be illimitable—varies, of course, with the nearness or remoteness of the affected bodies. Universal gravitation is a mathematical force, that is, *two bodies in space attract each other with a force proportional to their masses and inversely proportional to the square of the distance between them.*

This Newtonian law of gravitation is so remarkable and instructive that it will be interesting to apply it to our earth and her satellite. *Mass* is merely the quantity of matter in a body and the greater the masses of two bodies the greater is the attraction between them. For example, the mass of the moon being only about 1/81st that of the earth, the force of attraction between these two bodies would not be as great as the attraction between the sun and the earth, were our sun placed at the same distance from us as is our moon. But the second part of this law is still more interesting. The radius of our earth is approximately 4000 miles, in other words it is about 4000 miles to our earth's center. Now, at the terrestrial surface, there is such an attraction towards our earth's center that another body falls earthward with a velocity of about 16 feet during the first second, 64 during the second second, 402½ feet during the fifth second, and so on, that is, multiplying 16.1 feet by the square of the time. If we were able to rise 4000 miles above the world's surface, we should then be 8000 miles from the terrestrial center or twice as far from that center. Since two bodies attract each other with a force *inversely proportional to the square of the distance between them*, we should fall from this height of 4000 miles with a velocity ¼th of that with which we fall at the surface, about 4 feet during the first second, because being twice as far above our earth's center the square of $\frac{2}{1}$ would become inversely $\frac{1}{4}$—our speed of descent being ¼th of 16.1 feet.

Consequently, when 12,000 miles above the ground our rate of descent would become (16,000 divided by 4000 equals 4 or $\frac{4}{1}$, which squaring inversely is $\frac{1}{16}$) one-sixteenth of 16 feet or about 1 foot during the first second. Of course this lower speed of velocity would increase with every second thereafter.

Therefore, it is evident that were we to fall from a distance as great as that to the moon (her mean distance), about 239,000 miles, we should begin almost imperceptibly our descent homeward. This distance to the moon approximates 60 times as far as from the terrestrial surface to center, and, accordingly, the rate of descent would be about 1/3600th of 16 feet during the first second. And as we should expect, the so-called weight of one's body—a body weighing perhaps 150 pounds at the terrestrial surface—would have also decreased enormously at this remoteness above the terrestrial center. Indeed, the pull of the invisible chains at this height upon such a body would now register only 1/3600th of 150 pounds or about ⅔ of an ounce. But small as this terrestrial attraction is it appears more important when we consider that 3600 tons at our earth's surface would still be one ton at a remoteness of about 239,000 miles. Therefore, upon the total mass of the moon the invisible chains from earth must have strong influence, particularly when our moon is nearest to us, only about 217,000 miles from lunar surface to terrestrial surface.

But man is far more interested in the action of lunar gravity upon our earth than in the action of terrestrial gravity upon the moon. Were her invisible chains to be unshackled from our earth, the height and vigor of our tides would be woefully diminished. It is true that the sun would still raise some sort of tide, but the tidal influence of the moon is more than twice that of our sun. Of course when both sun and moon are united in producing what is known as "spring-tide" a very high tide results, and were the sun to withdraw his tidal action from our oceans we should certainly miss it. But the moon is the chief tide-raiser, assisted or opposed by the sun, according to the position of moon and sun relative to our world. When the moon is "in perigee", that is, nearest to the earth, the tides are about 1/5th higher than when she is "in apogee", farthest from the earth. Her efforts in drawing the ocean towards her and in drawing the land away from the ocean on the other side of the world raise the level of the water about two feet in mid-ocean, and, as the rotation of our earth causes the moon to move apparently towards the west, this raised water is influenced by her attraction to follow her. Thus, the tides produced by moon and sun rise and ebb upon the shores of our oceans. And the very same invisible chains, although they pull from different directions, both draw us to the ground and lift the waters in mid-ocean.

Upon our earth the action of these invisible chains is everywhere evident. We see it in the flow of rivers, the mill-wheel, the pile-driver, the falling rain, the avalanche, all about us. We see it outside of our earth—the planets, large and small, revolving around their sun, the satellites revolving around their planets, It is terrestrial and universal,

yet its real meaning, its cause, is not understood. It is a vital part of us, we are constantly assisted by it—but *what* is it? And not only universal gravitation but also universal electricity, universal light and other universalities are not comprehended by any of us. It may indeed be that gravitation, electricity and light are one and the same, under different conditions, or they may be the different expressions of some fundamental dynamic force or forces. Certainly it seems as though gravitation, electricity and light were very closely related, not only because they are universal but from several points of resemblance. All three are active agencies, stupendous mysteries of the mysterious Cosmos. Their roots lie far below the atom that was once believed to be the nucleus of material creation.

Chains which are invisible!—and innumerable. Perhaps a better description of universal gravitation would be "cables which are invisible." And indeed it may be that we are bound to our earth by invisible cables each of which is formed of a myriad of invisible chains. Most of us were taught to speak of the *force* of gravity when possibly it is more accurate to speak of the *forces* of gravity.

Newton, Mass.
41 Arlington St.

OBSERVATIONS OF THE TOTAL SOLAR ECLIPSE OF JUNE 8, 1918, AT MATHESON, COLORADO.

D. W. MOREHOUSE.

The Drake University Observatory eclipse expedition occupied a very favorable site at Matheson, Colorado. It was wholly through the courtesy of Dr. Edwin B. Frost, Director of the Yerkes Observatory, who with Professor E. E. Barnard, had selected this station as one of two very desirable locations, that the expedition was so happily situated.

There were four eclipse parties at this station. Professor Frank H. Loud was in charge of the company from Colorado Springs, Professor C. A. Chant represented the University of Toronto, Toronto, Canada. Professor Edison Pettit of Washburn College, directed the Yerkes Observatory detachment assigned to this site. The writer and his assistant manned the instruments of the Drake Observatory.

THE DRAKE UNIVERSITY TELESCOPE AND CAMERAS AT MATHESON, COLORADO.

The position of Matheson as determined by Professor Pettit and his party is:

Longitude $6^h\ 55^m\ 56^s$
Latitude $39°\ 10'$.

Professor Frank H. Loud determined its location with reference to the Rock Island Depot by triangulation, as follows:

Matheson Station (R. I. Depot) bears 50° 35′ East of North, distance 8430 feet.

The altitude is about 6000 feet.

Contacts.

The first and fourth contacts were observed by Pettit and myself through my 3-inch finder attached to the equatorial, by the projection method. Professor Pettit caught the first glimpse of the moon at $4^h\ 13^m\ 49^s.5$ and I caught it a half second later. The computed times of contact for this station as corrected by Professor Pettit are:

1st	contact	4^h	13^m	$42^s.6$	Mountain Summer Time
2nd	"	5	23	50.7	
3rd	"	5	25	19.2	
4th	"	6	28	03.7	

We were a little surprised that we should have been nearly seven seconds slow in our observed time, for the contact was very sharp and easily detected. The second and third contacts were not observed directly, every observer being busy with his program. The fourth contact was observed in the same manner as the first but the low sun, together with the clouds, made the observations very uncertain as the results show. Observed 4th contact $6^h\ 27^m\ 16^s$, Mountain Summer Time.

Bailey's Beads.

Bailey's Beads were observed by Professor C. C. Plitt of Baltimore City College, Baltimore, Md., by projection on a white screen through my three-inch finder. He reports that they appeared at $5^h\ 23^m\ 51^s$, Mountain Summer Time, which was just six seconds before time was called for the beginning of totality by the timekeeper. This agrees beautifully with the time for second contact, as computed by Professor Pettit. Professor Plitt said there were at least twenty-five beads and they were yellowish in color and very sharp.

The Flash Spectrum.

This was observed visually with a small direct-vision, slitless ocular spectroscope (such as is placed over the eyepiece of the telescope for

observing the spectrum of the stars) by my assistant, Mr. Donald Smith, who makes the following report: "The reversal of the Fraunhofer lines was observed at the instant preceding and at the instant following totality. The bright lines flashed out suddenly and lasted for approximately one second at each of the observations. Lines in the red and blue green (probably due to hydrogen) and in the yellow (probably the helium lines) were most conspicuous. There was a very large number of small lines in the yellow and yellow-green especially. A faint continuous spectrum served as a background.

The Shadow Bands.

Mrs. Stella Meek Whisler of Illinois College, Jacksonville, Illinois, observed this phenomenon by spreading upon the ground at the northwest corner of the shack a large piece of white oilcloth (about ten feet square). She reports as follows: "The shadow bands were very distinct and plainly visible just before and after the period of totality. They were black and white, each about one inch to one and one-fourth inches in width and three to four inches apart and traveled in the direction of northwest and southeast or parallel to the path of the shadow. They appeared by the hundreds and passed very rapidly, resembling ripples or waves on the water. They passed so rapidly I could not even guess at the number per second. The shadow bands were one of the many beautiful and interesting sights observed during the eclipse. In both instances they passed in the same direction and at the same angle. They lasted for two or three seconds on each occurrence."

Report of Shadow Bands in the Total Solar Eclipse of May 28, 1900.

It is interesting to compare the above observations of the shadow bands with similar reports made by members of Professsr C. A. Young's party at Wadesboro, N. C., May 28, 1900. I quote Astrophysical Journal Vol. 12, June-Dec. 1900. "These were satisfactorily observed by Mr. Reilly, Mr. Erdman and Mr. Meier upon two tent-flies, one inclined and nearly facing the eclipsed Sun, the other lying upon the ground. The bands first appeared about a minute and a half before totality, lying in a plane nearly tangent to the uneclipsed arc on the Sun's limb, about two inches wide, but wavy and irregular, separated by an interval of from five to seven inches and moving with a speed of about five or six miles an hour in the direction from southwest to northeast. As totality approached the interval between the bands diminished, till they were only an inch or two apart, and the speed of their apparent motion

increased enormously to the velocity of an express train. After totality they were more irregular, close together, with no decided progressive motion but simply quivering or oscillating. They lasted about a minute and a half before fading out."

Professor C. W. Crockett of Rensselaer Polytechnic Institute reports (see ibid) from observations at Juliette, Ga. "A sheet was spread horizontally, the corners being tacked to stakes driven in the ground. The observers reported that the bands were about the width of a man's hand, wavy and indistinct, and that it was impossible to count them."

Photographs of the Corona.

The three eclipse parties agreed upon a definite program. A break circuit chronometer owned by Professor Pettit operated three sounders, one in each shack. Professor P. F. Whisler of Illinois College, Jacksonville, Ill., acted as official timekeeper. Beginning five minutes before the computed time of totality he called each minute in the reverse order as, five, four, three, two and one. Miss Vera Gushee of Smith College at the appearance of the corona gave the signal to start by striking a large barrel with a hammer. This was the zero of our exposure time. At this signal Professor Whisler called out the half beats of the chronometer, as zero, and, one, and, two, and - - - - - - - -. In our practice I had been stopping on the eighty-sixth second, although our computed time gave us eighty-eight seconds.

With this program I secured six photographs of the corona, one with the five-inch photographic doublet and five with the eight and one-fourth inch equatorial, which was provided with a photographic lens of 120 inches focal length, by the John A. Brashear Co., and the regular driving clock. The photographic doublet was attached to the tube of the equatorial.

The photographs with the doublet and equatorial were taken simultaneously with forty seconds exposure from the eighteenth to the fifty-eighth second of our program. The five-inch negative is badly over-exposed. The corona merges into the sky effect and the prominences are reversed, that is they are light in the negative. A slender halo, also reversed, standing out away from the moon's disc, connects the top of two prominences which are about sixty degrees apart. The corona is distinctly triangular in shape. The long eastern streamer forms the vertex of an isosceles triangle and the western streamers diverge to form the base.

Only three star images (including Jupiter) are visible on this plate. Jupiter's image is very distinct but too near the edge of the plate to be good. Beta and Zeta Tauri are at the very limits of the field and their images appear as crescents.

Five photographs were taken with the 8¼ inch equatorial with the following exposures:

No. of plate	Exposure time	Exposure interval	Make	Remarks
1	0 Sec. to 1 Sec.	1 second	Seed 23	Backed
2	6 Sec. to 11 Sec.	5 seconds	" 30	"
3	18 Sec. to 58 Sec.	40 seconds	" 30	"
4	63 Sec. to 74 Sec.	11 seconds	" 30	"
5	81 Sec. to 86 Sec.	5 seconds	" 23	"

The 1 second and the 5 second exposures are the best plates. They were developed with metol-hydrochinon developer. The structure of the corona is well shown on both plates. The polar fans are very distinct and strong. Those about the north pole seem to be longer and not so sharply curved, and apparently more numerous, while at the south pole they are sharply curved, especially toward the west. The western half of the corona is full of detail. Three distinct petal-shaped extensions radiate from the center covering an arc of about 120 degrees. One quickly thinks of the appearance of the petals of a white wild rose.

Two straight rays extending from the southwest quadrant cross at a very definite measurable angle. The eastern streamer seems to have three straight rays, a little brighter than the general corona, extending through it at small angles to its general direction. Three remarkably bright prominences stand out over the moon's disc at approximately 120 degrees apart.

The 40 second and 11 second exposures were sent to Professor Barnard at Yerkes Observatory, who very kindly consented to develope them for me. As was expected the 40 second plate was badly overtimed, indeed to such an extent that the prominences were reversed. Professor Barnard stated in a letter to me that he did not know of a similar occurrence in eclipse negatives. The corona is nearly lost in the sky effect.

The 11 second plate is much better, but not as good as the shorter exposures.

Plate No. 5 is quite interesting. As noted above I stopped the exposure promptly at the 86th second although the signal to stop had not been given by the timer. The chromosphere is distinctly visible at the western edge of the moon's disc and is reversed, that is, light in the negative. At either end of the arc of the chromosphere is a prominence. The one at the southern end is extremely delicate in structure, resembling the skeleton of some prehistoric bird.

The unexpected brilliancy of both the prominences and the corona was the universal comment of all observers. The apparent indentation of the moon's disc at the base of the prominences was so conspicuous that the bystanders were eagerly inquiring the cause.

THE WEATHER.

The weather conditions on the day of the eclipse caused much anxiety. The day dawned with a cloudless sky, as most days do at this time of year in Colorado. The forenoon passed without the appearance of a cloud to mar the peace of mind of the observer or that beautiful blue firmament of which those western mountains alone can boast. A very gentle wind blew from the north, shifting slightly to the northeast. About noon the usual white cloud banks began to appear on the horizon. By two o'clock the sky was well dotted with large cumulus clouds. It was dramatic, at least for the observers, as one by one these beautiful forms floated lazily over the sun. About four-thirty thin cirrus clouds began to gather low on the western horizon. Several times between first and second contacts the sun was completely hidden behind these slowly moving clouds. However, not more than five minutes before totality, the sun came out between two great cumulus clouds and a large rift in the cirrus cloud bank floated leisurely over the sun. It was the most precious bit of blue sky I think I have ever seen. My first photograph shows a trace of the haze on the eastern limb of the moon. The other plates, however, do not indicate the slightest trace of a cloud. The fourth contact was observed through rather thick haze.

The darkness did not seem as intense as I had anticipated. The observers seemed to have no difficulty in reading the faces of their watches. It did not seem to me to be as dark as it is at full moon. Just before totality the temperature fell notably. The air felt very much like the air in a low swale or hollow at night. The prairie owls came out and gave their cries and the night hawks circled overhead. I heard distinctly the roosters at a near-by farm house crow several times after the shadow passed.

The phenomenon of the approaching shadow was a disappointment to all. No distinct outline was seen, either in the distance or just at the moment of totality. Like a flash the sun's light went out and we found ourselves in darkness. The receding shadow was more conspicuous. The sunlight seemed to be chasing the shadow over the distant hills. That weird unnatural appearance of the landscape, which was so notable before totality, did not follow the re-appearance of the sun.

[We had expected to reproduce two of Professor Morehouse's photographs which show more detail than that shown in Plate XVII in the August-September number of POPULAR ASTRONOMY, but unfortunately the engravers have failed to bring out the detail satisfactorily. EDITORS.]

ON THE REPORTED NAKED-EYE OBSERVATIONS OF NOVA AQUILAE III PREVIOUS TO 1918 JUNE 8.

E. E. BARNARD.

It is very important that we should know the early life history of the novae. The transition from a state of quiet to one of great activity is so abrupt, and the rise in brightness so rapid, that these stars are rarely caught before they are on the decline. They are wholly unknown (though they may be on our photographs) before their outburst and we cannot, therefore, be prepared to watch the increase in brightness. Indeed it is almost entirely to photography that we owe our knowledge of the early history and the rise to maximum of these strange bodies. Nova Persei (Anderson), the great star of 1901, was fortunately observed on its rise, and Harvard photographs give us much information of its pre-nova existence. Nova Geminorum II (Enebo) was also fortunately caught in an early stage and something is known of its previous history.

Nova Aquilae III of the present year (1918) was caught on its rise to maximum, both visually and photographically. Though the photographic history is very clear and satisfactory as to the pre-nova existence of the present star and the time of its rise to maximum, which is verified in part by the best visual observers, there has come up, in spite of this very satisfactory evidence, a number of statements that might lead to an erroneous idea of the time at which the activity of the star began. According to some of these observations the nova would seem to have slowly dragged its period of increase of light, as a bright naked-eye star, with fluctuations, over something like two weeks before the actual outburst occurred. It is hard not to believe some of these observations, where the evidence is apparently given with such candor, albeit they do not seem to come from experienced observers. On the face of the photographic evidence, however, which is supported by good visual observations, we must reject them as at least visionary or due to a confusion of dates. The photographic evidence is incontestable. None of these questionable reports has originated in America.

Of those pre-outburst claims perhaps the most curious, and yet apparently real, observations are by E. Breson and his wife, at Helsingör, Denmark. These are given in A. N. 4949.

1918	[?]	G.M.T. h m	Estimates	Mag.
June 6	[9]	10 30	Nova 3 Arcturus	Nova = −0.06
7	[10]	10	" 3 "	−0.06
8	[11]	10	" 2 "	+0.04
9	[12]	10 10	" 0 "	+0.24
10	[13]	10 5	Arcturus 0.5 Nova	+0.29

The above would make the nova brighter than Vega and Arcturus on the 6th and 7th of June, which we know did not occur until June 9. As they stand, these observations cannot be true. The only probable explanation of them is that there is a confusion of dates, which is possible in these trying times in Europe. If we advance the dates three days the results in part are satisfactory. In the above table I have introduced a column with the dates corrected on this assumption. The only objection to this is that the last two dates (especially the last one) would make the star too bright.

Briefly, what we actually know of the history of this star from the photographs is this. Previous to its outburst, certainly as far back as 1888, the object existed as a star of the tenth or eleventh magnitude, which seemed to fluctuate irregularly in its light. Harvard photographs (and there are over 400 of them covering the period from 1888 to the time of the outburst of light) show the star on June 3, 1918, in its normal condition. Clouds prevented other photographs there until June 7 between 18^h and 19^h G. M. T. when three different plates show the nova on the rise and of the sixth magnitude. A number of observers in various parts of the world discovered it independently as a first magnitude star on the evening of June 8. It attained its maximum brightness on June 9, when, by actual comparison, Mr. J. T. Ward, Director of the Wanganui Observatory, New Zealand, found it brighter than Canopus, which would make it close to magnitude -1. My own observations would make it ever brighter. The star, therefore, rose through perhaps 12 magnitudes, which would mean over fifty thousand fold increase of light.

From the Harvard photographs there is an uncertainty of some three or four days as to the time of rise, because of cloudy skies. Happily two photographs were made of the region of the nova by Dr. Max Wolf at Heidelberg, Germany, on June 5, $9^h\ 44^m$ to $13^h\ 4^m$ G. M. T., which show the star in its normal condition of 10.5 magnitude. The outburst actually occurred, therefore, between June 5 and June 7, in all probability on June 6.

In A. N. 4949 and 4950 there are some observations of the nova by W. J. Luyten at Deventer, Holland, who states that when observing in the region of θ Serpentis—presumedly with the naked eye—on June 6 at $12^h\ 8^m$ G. M. T. he saw a star which was much fainter than 64 Serpentis and with which he was unfamiliar. On examining the BD charts he found that what he had seen was probably BD $+\ 0°4027$ ($6^m.5$). On June 7 he made a rough sketch of the stars in the neighborhood of 4 Aquilae and 64 Serpentis, and on June 8 he found the nova at this point as a first magnitude star. Mr. Luyten has recorded this as a very doubtful observation of the nova on June 6. His observation is

so close to the actual time of the outburst of the nova that some, not knowing of the photographs at Harvard and Heidelberg, might suppose that the star was seen with the naked eye as early as June 6. From the light curve given in H. C. O. Circular 208, however, the nova would certainly have been beyond naked eye visibility on that date. The star BD $+0°4027$, whose Harvard magnitude is 6.26, is about 20′ northeast of the nova. It is more probable that the object seen on June 6 and 7 was this star and not the nova, and that the observation is only another one of those remarkable coincidences that have often happened in astronomy. I am more readily impressed with this belief from the fact that BD $+ 0°4027$, though fainter than the nova, can now be distinctly seen with the naked eye close northeast of it. This star has given much trouble of late in the naked eye observations. The two stars, when not well seen, blend together and give the nova a blurred or hazy look which is not real. If the nova had been visible at the observations on June 6 and 7 the observer would have seen two stars at this point instead of one. It is evident that the same star was seen on both June 6 and 7. Mr. Luyten's observations are really excellent negative evidence and are very important. As he seems to have seen only one star on the 6th and 7th of June, it shows that the nova was not then visibie to the naked eye, though it would undoubtedly have been seen later on in the night of June 7.

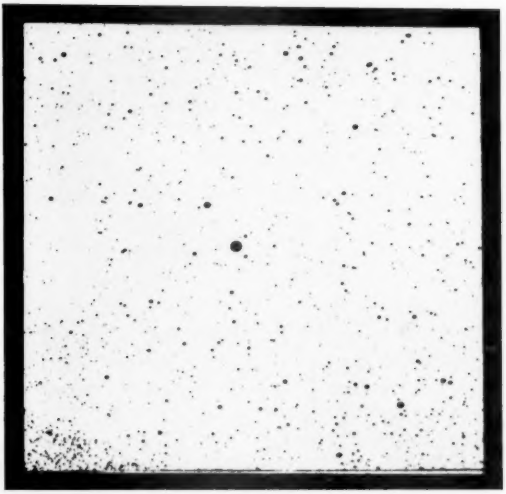
One of the most satisfactory proofs that the nova was not bright on June 7 is the following. Mr. Frank Sullivan, in the absence of the regular observers on the eclipse expedition, made a photograph of the spectrum of 4 Aquilae with 100 minutes exposure with the Bruce spectrograph of the 40-inch telescope of the Yerkes Observatory the last thing before daylight on the morning of June 8. He is a careful observer and would not have failed to notice a strange bright star only $1\frac{1}{2}°$ from the star he was photographing! The nova undoubtedly was visible to the naked eye at that time, but not bright enough to attract attention.

The best that can be made from the various reported observations and the evidence given by the photographs is that there is no justifiable claim that the nova was seen with the naked eye previous to June 8, 1918. The time of the beginning of the increase of light certainly lies between the dates 1918 June $5^d\ 13^h\ 4^m$ G.M.T. and June $7^d\ 18^h$ G.M.T.

As previously stated in this journal (The August-September number, 1918, Vol. XXVI, p. 492) the star is shown on my plates on 54 dates previous to the outburst, the first one being 1892 June 29 and the last one 1917 March 20. Four of these were made at the Lick Observatory with the 6-inch Willard lens. Its light was subject to slight variations and the star seemed to be fainter in 1917. Two of my photographs of

PLATE XXII

NORTH



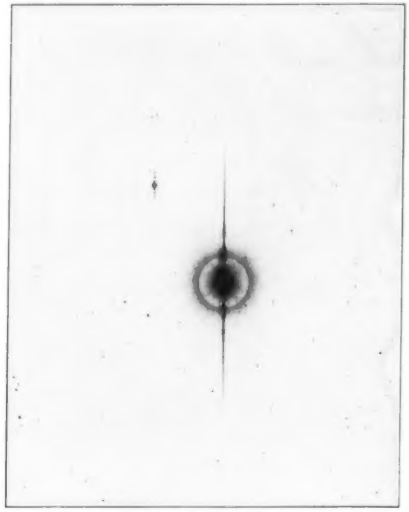
1918 July 12, $16^h\ 58^m$ G.M.T. Exposure $2^h\ 5^m$

1905 July 9, $21^h\ 48^m$ G.M.T. Exposure $3^h\ 5^m$

PHOTOGRAPHS OF NOVA AQUILAE III
After and Before the Outburst

PLATE XXIII

June 7.785 G.M.T. Magnitude 6.2.



June 8.830 G.M.T.

PHOTOGRAPHS OF NOVA AQUILAE III TAKEN AT HARVARD COLLEGE OBSERVATORY WITH THE 16-INCH METCALF TELESCOPE

the nova accompany this paper. Both were made with the 10-inch Bruce lens of the Yerkes Observatory, showing the star before and after the outburst. The nearest considerable star northeast of the nova is BD + 0°4027.

Yerkes Observatory,
Williams Bay, Wis.
1918 Sept. 12.

THE GEGENSCHEIN IN THE FIRST HALF OF OCTOBER.

E. E. BARNARD.

The gegenschein will be very favorably placed for observation as soon as the present moon withdraws, say in the first half of October. Before the middle of October it will be large and round, 20° or 30° in diameter. I have found it sometimes as much as 50° or 60° in diameter. It is very easily seen as a very large diffused area somewhat brighter towards the middle. It is best seen by directing the eyes about 60° to the west of its position and then turning the eyes, without turning the head, in its direction. As a help to those who want to look for it, I give the following rough ephemeris of its position.

	α		δ
	h	m	°
Oct. 1	0	30	+ 3
5	0	45	+ 4½
10	1	03	+ 6½
15	1	22	+ 8½

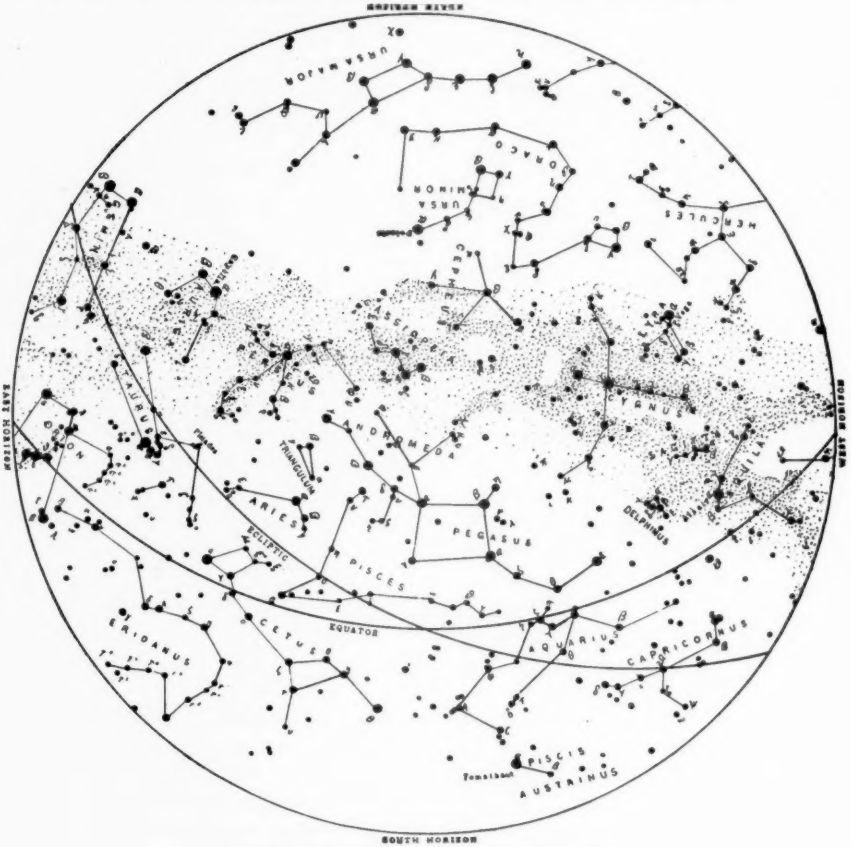
It is best seen when on the meridian at midnight, but can be seen as early as $9^h\ 30^m$ or $10^h\ 0^m$. There must be no moonlight. The sky must be clear and not hazy. There must be no artificial light near to blind one. Above all do not look for a small difficult object. It is like a large spot of haze, almost conspicuous when best seen.

For an extended account of the gegenschein and its history I would refer the reader to an article of mine in POPULAR ASTRONOMY for April 1899, Vol. 7, pp. 1-11.

Yerkes Observatory,
Williams Bay, Wis.
1918 Sept. 14.

PLANET NOTES FOR NOVEMBER, 1918.

The sun will be descending the slope of the ecliptic from — 14° to — 21° declination during this month, so that the days will be much shorter than the nights.



THE CONSTELLATIONS AT 9:00 P. M. NOVEMBER 1.

The phases of the moon in November will be

New Moon	Nov.	3	at	3	P.M. C.S.T.
First Quarter		11	"	11	A.M. "
Full Moon		18	"	2	A.M. "
Last Quarter		25	"	4	A.M. "

Mercury having passed superior conjunction, behind the sun, on October 15, is now evening star but coming out so slowly from proximity to the sun that it will not be easily visible to the naked eye until the latter days of November. It will be at greatest elongation, 21° 30′ east from the sun, on November 29 at 10 p.m. Central Standard time. At that time Mercury will be too far south to be easily seen by northern observers, but to those in the southern hemisphere it will be a conspicuous object about three quarters of an hour after sunset.

Venus will be at superior conjunction on November 23 and so will be lost in the sun's rays during this month.

Mars is between two and three hours east of the sun, but is so far south that northern observers will not be able to observe it. It is moving eastward through the constellation Sagittarius and is brighter than any of the stars in its vicinity.

Jupiter may be seen rising in the northeast at about 9 o'clock in the evening on November 1. It may be observed best in the morning, crossing the meridian at 4:26 a. m. local time on November 1 and at 2:27 a. m. on November 30. It is near the middle of the constellation Gemini, stationary on November 3 and after that moving slowly westward.

Saturn will be at quadrature, 90° west from the sun on November 20, rising then a few minutes before midnight, local time. Saturn is in the constellation Leo a little northeast from the first magnitude star Regulus. The two objects will be only a little more than a degree apart at the end of the month.

Uranus is almost stationary in the eastern part of the constellation Capricorn, about two degrees north and a little east of the star δ. It will be at quadrature, 90° east from the sun, on November 16.

Neptune will be at quadrature, 90 west from the sun, on November 2. It will be stationary, turning the eastern end of the loop in its annual path, on November 12. It is in the constellation Cancer about a degree and three quarters east and less than a degree south of the star δ. Neptune cannot be seen without the aid of a telescope.

Occultations Visible at Washington.

[*From the American Ephemeris.*]

Date 1918	Star's Name	Magnitude	IMMERSION. Washington M.T. h m	IMMERSION. Angle from N. °	EMERSION. Washington M.T. h m	EMERSION. Angle from N. °	Duration h m
Nov. 7	21 G Sagittarii	5.7	4 26	90	5 45	244	1 20
8	ζ Sagittarii	3.7	5 45	126	6 29	195	0 44
8	36 Sagittarii	5.1	6 05	0	6 30	322	0 26
16	27 Arietis	6.4	15 00	49	15 52	291	0 52
18	51 Tauri	5.6	5 30	39	6 08	299	0 38
18	247 B Tauri	5.8	9 23	137	10 00	200	0 37
19	*o* Tauri	4.8	7 28	86	8 24	262	0 56
20	15 Geminorum	6.5	7 04	79	7 54	282	0 50
20	16 Geminorum	6.2	7 22	155	7 44	206	0 22
21	*f* Geminorum	5.3	13 42	128	14 59	265	1 18
23	ω Leonis	5.5	17 59	164	19 01	259	1 03
24	14 Sextantis	6.3	11 50	164	12 25	236	0 36
25	237 B Leonis	6.3	11 52	154	12 34	248	0 42
25	55 Leoins	6.1	13 38	136	14 42	275	1 04

Phenomena of Jupiter's Satellites.

VISIBLE AT WASHINGTON.

[*From the American Ephemeris.*]

CENTRAL STANDARD TIME.

1918	h	m		
Nov. 1	16	09	I	Ec. D.
2	13	31	I	Sh. I.
	14	41	I	Tr. I.
	15	45	I	Sh. E.
	16	55	I	Tr. E.
3	10	37	I	Ec. D.
	14	04	I	Oc. R.
4	9	08	I	Tr. I.
	10	13	I	Sh. E.
	11	23	I	Tr. E.
5	8	31	I	Oc. R.
	15	20	II	Sh. I.
6	13	01	III	Sh. I.
	16	02	III	Sh. E.
7	10	27	II	Ec. D.
	15	25	II	Oc. R.
8	9	42	IV	Oc. R.
9	9	31	II	Tr. E.
	15	25	II	Sh. I.
	16	30	I	Tr. I.
10	10	21	III	Oc. R.
	12	31	I	Ec. D.
	15	53	I	Oc. R.
11	9	53	I	Sh. I.
	10	57	I	Tr. I.
	12	07	I	Sh. E.
	13	11	I	Tr. E.
12	10	20	I	Oc. R.
13	16	59	III	Sh. I.
14	13	02	II	Ec. D.
	17	48	II	Oc. R.
16	8	09	IV	Sh. E.
	9	14	II	Tr. I.
	9	51	II	Sh. E.
	11	54	II	Tr. E.
	15	53	IV	Tr. I.
	17	18	I	Sh. I.
	17	59	IV	Tr. E.
17	9	48	III	Ec. R.
	10	43	III	Oc. D.

1918	h	m		
Nov. 17	13	55	III	Oc. R.
	14	25	I	Ec. D.
	17	40	I	Oc. R.
18	11	47	I	Sh. I.
	12	44	I	Tr. I.
	14	01	I	Sh. E.
	14	59	I	Tr. E.
19	8	53	I	Ec. D.
	12	07	I	Oc. R.
20	8	29	I	Sh. E.
	9	25	I	Tr. E.
21	15	37	II	Ec. D.
23	9	47	II	Sh. I.
	11	35	II	Tr. I.
	12	27	II	Sh. E.
	14	16	II	Tr, E.
24	10	41	III	Ec. D.
	13	47	III	Ec. R
	14	12	III	Oc. D.
	15	16	IV	Ec. D.
	16	19	I	Ec. D.
	16	40	IV	Ec. R.
	17	24	III	Oc. R.
25	9	19	II	Oc. R.
	13	40	I	Sh. I.
	14	31	I	Tr. I.
	15	54	I	Sh. I.
	16	45	I	Tr. I.
26	10	47	I	Ec. D.
	13	53	I	Oc. R.
27	8	09	I	Sh. I.
	8	57	I	Tr. I.
	10	23	I	Sh. E.
	11	12	I	Tr. E.
28	7	20	III	Tr. E.
	8	20	I	Oc. R.
30	12	23	II	Sh. I.
	13	54	II	Tr. I.
	15	03	II	Sh. E.
	16	36	II	Tr. E.

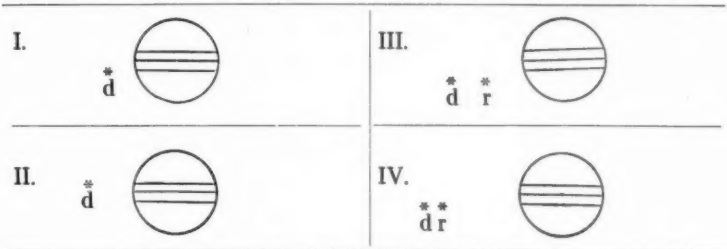
Note:—I., denotes ingress; E., egress; D., disappearance; R., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

Satellites of Jupiter, 1918.

GREENWICH MEAN TIME.

NOVEMBER

Phases of the Eclipses of the Satellites for an Inverting Telescope.



Configurations at 18h 30m for an Inverting Telescope.

Day	West	East
1	·3 ·1 ○ 2·	
2	4· ·3 2· ○1·	
3	4· ·2 ○ ·3	·1●
4	·4 1· ○ ·2 ·3	
5	·4 ○ 2·1 3·	
6	·4 2· 1· ○ 3·	
7	3··4 ○ 1·	·2●
8	3· 1. ○·4 2·	
9	·3 2· ○ 1· ·4	
10	·2 ·1○ ·3 ·4	
11	○1· ○ ·2 ·3 ·4	
12	○ ·12· 3· ·4	
13	2· 1· ○ 3· 4·	
14	3. ·2 ○ ·1 4·	
15	3· ·1 ○ ·2·4	
16	·3 2·4○· 1·	
17	·4·2 ·1○	·3●
18	4· 1○· ·2 3·	
19	4· ○·1 2· 3·	
20	4· 2· 1· ○ 3·	
21	·4 3· ·2 ○ ·1	
22	·4 3· 1· ○ ·2	
23	○2· ·4·3 ○ 1·	
24	·2 ·4 1· ○	·3●
25	○1··2·4 ·3	
26	○ 2· 3··4	·1●
27	2· 1· ○ 3· ·4	
28	·3 2· ○ ·1 ·4	
29	3· 1. ○ ·2 4.	
30	·3 ○2· 1· 4·	

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes and Frank M. Exner at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1918 November							
	h m	° ′		d h	d h	d h	d h	d h				
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8				17 15				
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	3 2;	10 18;	18 10;	26 3				
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	2 20;	10 7;	17 17;	25 4				
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	4 19;	12 7;	19 18;	27 6				
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	4 13;	10 16;	16 19;	29 0				
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	6 16;	13 19;	20 22;	28 2				
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	4 11;	11 8;	18 5;	25 1				
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	6 13;	13 17;	20 21;	28 2				
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	3 1;	16 19;	25 14					
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	6 0;	13 23;	21 21;	29 20				
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6	8 1							
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	5 1;	10 19;	16 12;	28 2				
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	7 19;	14 14;	21 9;	28 4				
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	4 3;	12 1;	19 22;	27 20				
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	4 19;	13 2;	21 9;	29 17				
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	7 14;	15 11;	23 8;	27 7				
RW Persei	13.3	+42 04	8.8—11.0	13 04.8	7 13;	20 18						
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	2 21;	12 7;	21 18;	28 1				
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1		11 18;	24 4					
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	6 15;	13 7;	19 23;	26 15				
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	4 21;	13 1;	21 5;	29 10				
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	2 0;	8 1;	20 2;	26 2				
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	1 0;	9 16;	18 8;	27 0				
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	9 13;	19 23;	30 8					
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	2 3;	10 3;	18 3;	26 3				
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	6 14;	12 8;	18 2;	23 19				
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	2 15;	8 6;	13 20;	25 1				
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	1 2;	9 6;	17 11;	25 16				
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	6 12;	14 3;	21 18;	29 9				
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	3 2;	15 7;	27 12					
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	4 15;	11 19;	18 23;	26 3				
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	7 16;	14 12;	21 8;	28 3				
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	4 22;	14 6;	23 13					
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	1 8;	7 23;	21 14;	27 19				
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	8 10;	16 20;	25 5					
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	4 2;	10 13;	16 23;	29 20				
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	2 21;	10 4;	17 10;	24 17				
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	8 16;	16 19;	24 22					
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	6 16;	16 3;	25 15					
RX Hydrae	9 00.8	− 7 52	9.1—10.5	2 6.8	2 10;	9 6;	16 2;	29 19				
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	6 2;	12 1;	17 23;	29 20				
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	7 11;	14 5;	20 23;	27 17				
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	3 2;	10 12;	17 23;	25 9				
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	6 2;	12 16;	19 7;	25 21				
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	9 10;	18 5;	27 10					
RW Urs. Maj.	35.4	−52 34	10.3—11.4	7 07.9	6 1;	13 9;	20 16;	28 0				
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	6 8;	13 3;	19 22;	26 17				
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	6 18;	14 6;	21 18;	29 6				
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.1	1 18;	11 8;	20 23;	30 13				
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	5 3;	12 13;	20 0;	27 10				
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	4 18;	11 18;	18 17;	25 17				

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1918 November
	h m	° ′		d h	d h; d h; d h; d h; d h
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	7 14; 14 12; 21 10; 28 7
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.3	5 21; 14 7; 22 17; 28 8
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	7 7; 14 23; 22 15; 30 7
SW Ophiuchi	16 11.1	− 6 44	9.2—10.0	2 10.7	7 22; 15 6; 22 15; 29 23
SX Ophiuchi	12.6	− 6 25	10.5—11.2	2 01.5	4 20; 13 2; 21 8; 29 14
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	3 22; 12 18; 21 15; 30 11
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	2 3; 11 19; 22 21
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	5 9; 12 5; 19 0; 25 19
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	5 1; 13 11; 21 20; 30 5
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	1 20; 14 3; 20 7; 26 11
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	3 14; 10 19; 18 0; 25 5
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	5 2; 12 11; 19 20; 27 5
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	8 16; 16 20; 25 0; 29 1
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	4 4; 11 17; 19 6; 26 18
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	1 5; 8 23; 16 17; 24 11
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	8 8; 16 8; 24 8
WX Sagittae	53.6	−17 24	9.2—10.8	2 03.1	8 19; 17 7; 25 20
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	1 15; 10 23; 20 7; 29 15
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	5 19; 10 23; 21 7; 31 15
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	7 10; 14 16; 21 22; 29 4
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	5 9; 12 7; 19 4; 26 2
RZ Scuti	21.1	− 9 15	7.4— 8.3	15 03.2	11 5; 26 8
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	3 19; 10 23; 18 3; 25 7
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	6 22; 14 1; 21 4; 28 7
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	4 20; 13 4; 21 11; 29 19
RR Draconis	40.8	+62 34	9.3—13	2 19.9	3 19; 12 7; 20 19; 29 6
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	3 18; 10 9; 23 16; 30 7
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	4 11; 17 9; 30 7
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	6 19; 14 11; 22 2; 29 17
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	7 22; 15 12; 23 2; 30 16
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	8 2; 15 7; 22 11; 29 6
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	6 16; 15 15; 24 14; 29 2
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	5 20; 12 14; 19 8; 26 3
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	5 22; 13 7; 20 16; 28 0
TT Lyrae	24.3	+41 30	9.4—11.6	5 05.8	5 23; 11 5; 21 17; 26 23
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	6 13; 13 1; 19 14; 26 2
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	2 11; 8 11; 14 11; 26 11
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	3 11; 10 3; 16 18; 23 9
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	9 2; 18 6; 27 9
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	6 5; 14 15; 23 2
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	4 18; 11 13; 18 8; 25 3
UW Cygni	19.6	+42 55	10.5—13	3 10.8	7 14; 14 11; 21 9; 28 6
V Vulpec.	32.3	+26 15	8.2—9.8	37 19.0	30 18
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	10 11; 20 2; 24 21; 29 17
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	6 6; 15 10; 24 15; 29 6
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	7 9; 14 21; 22 9; 29 21
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	1 20; 9 11; 17 1; 24 15
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	5 11; 15 13; 25 16; 30 17
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	3 3; 10 12; 17 22; 25 7
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	9 6; 14 2; 18 22; 28 15
RY Aquarii	14.8	−11 14	8.8—10.4	1 23.2	6 5; 14 2; 21 23; 29 20
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3	12 15
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	1 22; 7 0; 12 1; 22 5
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	5 3; 10 7; 15 12; 25 21
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.3	4 9; 12 16; 21 23; 29 6
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	1 2; 8 14; 16 3; 23 16
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	4 3; 12 9; 20 15; 28 21

Maxima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1918. November							
	h m	° ′		d h	d	h	d	h	d	h	d	h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7								
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	2	2;	10	5;	18	9;	26	12
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	7	17;	15	11;	23	5;	30	23
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	4	3;	18	22				
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	3	14;	11	13;	19	11;	27	10
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	8	10;	16	6;	20	3;	24	0
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	2	7;	9	14;	16	21;	24	4
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	7				23			
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	5	22:	14	12;	23	2;	27	9
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	5	23;	17	3;	28	6		
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0			10	1;	21	17		
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	6	13;	14	5;	21	21;	29	12
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3			19	11;	20	15;	30	18
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	5	18;	13	12;	21	5;	28	22
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	3	22;	9	11;	14	23;	26	1
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	1	0;	8	14;	16	3;	23	17
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3							26	4
RT Aurigae	23.0	+30 33	5.1— 6.0	3 17.5	2	15;	10	2;	17	13;	25	0
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	5	6;	12	11;	19	16;	26	21
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	4	17;	12	15;	20	13;	28	11
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	3	4;	13	8;	23	12		
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5					23	3		
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	2	15;	10	13;	18	12;	26	11
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	4	16;	11	8;	18	1;	24	18
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	4	17;	9	8;	18	15;	27	22
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	3	10 ;	12	4;	20	22;	29	16
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 0.00								
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	4	4;	10	23;	17	17;	24	12
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	4	22;	11	13;	18	3;	24	18
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	6	23;	16	15;	26	7		
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	8	18;	16	17;	24	17		
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	3	22;	10	15;	17	9;	24	2
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	2	17;	14	9;	20	5;	26	0
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	4	7;	9	0;	18	9;	27	18
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5			15	18				
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	7	5;	15	10;	23	15		
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	6	0;	13	0;	20	1;	27	1
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	5	22;	14	3;	22	9;	30	14
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	5	23;	11	11;	16	22;	27	22
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	4	22;	12	11;	20	0;	27	13
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	7	23;	15	9;	22	18;	30	4
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	3	23;	10	18;	17	12;	24	7
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	4	23;	11	6;	7	14;	23	22
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	6	23;	16	17;	26	11		
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	9	13;	18	9;	22	19;	27	6
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	2	14;	8	15;	14	17;	26	20
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	7	13;	14	13;	21	14;	28	14
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9			13	10;	30	13		
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	6	7;	13	22;	21	12;	29	2
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	2	21;	8	16;	14	10;	25	23
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	4	9;	11	3;	17	20;	24	14
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	6	15;	17	0;	27	8		
Y Lyrae	18 34 2	+43 52	11.3—12.3	0 12.1	3	3;	9	4;	15	5;	27	6

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1918. November							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h
RZ Lyrae	18 39.9	+32 42	9.9—11.2	0 12.3	6 10;	12 13;	18 16;	30 23				
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	6 9;	12 7;	18 6;	24 5				
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	4 14;	13 16;	22 18					
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	2 6;	9 6;	16 6;	23 7				
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	5 23;	12 23;	19 23;	26 23				
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	3 0;	11 0;	18 23;	26 23				
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	3 18;	11 10;	19 3;	26 20				
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	5 3;	12 7;	19 12;	26 16				
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	1 8;	9 17;	18 2;	26 11				
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	2 0;	8 8;	14 16;	27 7				
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	8 6;	24 15						
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	2 9;	6 20;	15 17;	24 14				
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	4 5;	10 23;	17 16;	24 10				
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	1 11;	8 4;	14 21;	28 7				
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	4 12;	19 6						
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	5 21;	13 17;	21 14;	29 10				
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	6 21;	13 18;	20 15;	27 13				
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	3 2;	7 22;	17 16;	27 9				
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	8 13;	17 5;	25 21;	30 5				
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	5 9;	10 13;	16 3;	26 20				
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	4 15;	15 12;	26 10					
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	2 6;	8 16;	15 2;	27 23				
V Lacertae	44.5	+55 48	8.5— 9.5	4 23.6	1 7;	6 6;	16 5;	26 5				
X Lacertae	22 45.0	+55 54	8.2— 8.6	5 10.7	3 2;	8 13;	19 11;	30 8				
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	2 2;	7 12;	18 10;	29 7				
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	6 2;	12 9;	18 16;	25 0				
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4		10 5;	22 9					
V Cephei	23 51.7	+82 38	6.0—7.0	0 23.9	1 4;	6 4;	16 3;	26 3				

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, July, August, September, 1918.

In order to comply with the request of the editor of POPULAR ASTRONOMY that we reduce the length of the reports in order to conserve paper, the negative observations will hereafter be omitted. Observers are urged to avoid too frequent observation of the same variable. One observation a month will be sufficient for the great majority of the long period variables. This statement does not apply to the Nova and the irregular variables, which should be observed at every opportunity.

Mr. Irvin L. Murray of Valhalla, N. Y., contributes observations to this report designated by the abbreviation "My".

We have five applications for membership, including one Life Membership. These applications will be acted on at the Annual Meeting in November.

The Association is indebted to Mr. Lacchini for copies of his published observations,—a valuable addition to our records.

Mr. Forest H. Spinney's name is to be added to our Honor Roll of men in the Service.

Variable Star Observations July, Aug., Sept., 1918.

July 0 = 2421775

001046
X Androm.

J.D.	Est	Obs.
242		
1789.7	13.2	M
1807.7	13.5	B

001032
S Sculptoris

1705.9	10.3	δ
50.9	11.8	
80.7	12.5	

001620
T Ceti

1788.6	6.5	L
1810.6	5.8	

001726
T Androm.

1789.7	13.4	M
1807.7	13.3	B

001755
T Cassiop.

1686.	11.7	Lt
1732	10.2	
37	9.2	
50	9.2	
61	8.9	L
81	7.7	M
83	8.1	B
83.4	8.4	L
1807.7	8.2	M
19.6	8.0	B
33.7	7.7	
38.6	7.8	O

001838
R Androm.

1789.7	10.8	M
1804.3	9.4	Pe
06.4	9.6	
07.7	9.2	B
07.8	9.4	M
09.8	8.9	V
10.7	9.5	Pt
28.6	7.1	B
35.7	6.8	Pt
37.6	7.1	V

001909
S Ceti

1788.8	8.4	M
1807.8	8.4	
11.9	8.8	Pt

*002438*a
T Sculptoris

1750.9	9.5	δ
80.7	9.4	

*002438*b
RR Sculptoris

1750.9	13.0	δ
80.7	12.7	

002546
T Phoenicis

J.D.	Est.	Obs.
242		
1750.9	13.5	δ
80.7	13.9	

002614
T Piscium

1807.8	9.7	M

002833
W Sculptoris

1750.9	13.1	δ
80.7	12.9	

003179
Y Cephei

1776.6	12.7	Ba
93.7	11.1	B
1823.7	9.3	
33.6	9.0	Ba
34.6	9.3	Wh

004047
U Cassiop.

1686	11.7	Lt
1789.7	12.8	M
1898.8	12.8	B
33.6	12.0	Ba
34.7	11.7	Wh

004132
RW Androm.

1807.8	11.1	M

004435
V Androm.

1807.7	11.0	B
12.8	10.9	M
34.6	9.8	B
37.6	9.7	V

004533
RR Androm.

1751.5	9.0	Lt
60.5	8.4	
81.8	8.5	M
1807.7	9.9	B
09.9	9.4	V
12.8	10.6	M
28.6	9.9	B

004746a
RV Cassiop.

1781.8	9.4	M
83.7	9.2	B
1809.7	10.2	
12.8	10.8	M
33.6	11.9	B
33.6	11.7	Ba
34.7	11.8	Wh

Aug. 0 = 2421806

004958
W Cassiop.

J.D.	Est.	Obs.
242		
1686	11.8	Lt
1750	10.4	
76.8	9.7	M
83.7	9.1	B
1802.7	8.9	
12.8	9.8	M
25.6	9.3	B
34.6	8.7	Wh
38.6	9.0	O

010940
U Androm.

1807.7	12.9	B
33.6	11.2	Ba
34.6	11.2	B

011272
S Cassiop.

1750	9.8	Lt
60.5	9.4	
83.7	8.5	B
88.8	8.4	M
18097.	8.5	B
11.8	8.8	M
27.6	8.5	
33.6	8.6	Ba
34.6	8.7	Wh

011208
S Piscium

1834.7	13.0	B

012350
RZ Persei

1693.4	10.4	Lt
1716.5	9.6	
51.5	9.6	
1833.7	10.7	B

012505
R Piscium

1812.8	10.0	M

013238
RU Androm.

1776.8	11.7	M
1823.7	13.3	B

013338
Y Androm.

1685.3	10.5	Lt

014958
X Cassiop.

1686	13.1	Lt
1750	12.8	
56.5	12.8	
76.8	12.4	M
83.7	11.1	B
1819.6	12.1	
33.7	10.5	
37.7	11.6	M

Sept. 0 = 2421837

015354
U Persei

J.D.	Est.	Obs.
242		
1685.3	11.0	Lt
1740	9.7	
51	9.1	
76.8	8.3	M
1811.8	8.1	
19.7	8.1	B
33.7	8.2	

015912
S Arietis

1812.8	11.3	M

021024
R Arietis

1689	8.3	Lt
1792.6	12.3	L
1810.6	11.2	
11.8	11.0	M

021143
W Androm.

1688.3	10.8	Lt
1724.6	9.2	
51.5	8.2	
60.5	7.9	
88.8	9.3	M
1811.8	9.7	
23.7	10.2	B

021281
Z Cephei

1753.5	11.6	Lt
61	11.5	
92.8	11.4	M
1811.8	11.6	

021403
o Ceti

1788.5	7.9	L
92.5	7.1	
1802.9	5.0	M
06.6	6.0	Pe
10.6	5.4	L
11.8	4.6	M
11.9	5.3	Pt
18.8	4.5	M
37.7	3.5	Pt

021558
S Persei

1802.9	9.4	M
11.8	9.3	
19.7	9.3	B
34.6	9.0	

022000
R Ceti

1818.8	11.2	M

022150
RR Persei

1833.7	13.5	B

023080
RR Cephei

J.D.	Est.	Obs.
242		
1688.8	10.1	Lt

023132
R Trianguli

1686.3	8.8	Lt
1750.5	7.2	
56.5	7.3	
87.8	8.2	M
1807.8	9.5	
1833.7	9.7	B

024215
T Arietis

1685.3	8.6	Lt

024356
W Persei

1787.8	9.8	M
1802.8	10.1	
11.9	9.6	Pt
19.8	10.4	M
33.7	10.1	B

025751
T Horologii

1701.5	9.4	δ
12.4	8.3	
17.4	8.3	
50.9	8.0	
80.7	10.0	

031424
S Fornacis

1701.4	8.6	δ
12.4	8.7	
50.9	8.8	

031401
X Ceti

1810.6	11.7	L

032043
Y Persei

1802.8	9.5	M
19.8	9.8	

032335
R Persei

1685.3	11.9	Lt
1819.8	10.0	M

033362
U Camelop.

1686.4	8.7	Lt
1704.4	8.9	
24.4	8.9	
31	8.9	
39.9	9.0	
51	8.7	
76.6	7.2	Ba
1802.8	7.0	M
19.8	7.5	

VARIABLE STAR OBSERVATIONS, July, Aug., Sept., 1918—Continued.

034625
U Eridani

J.D. 242	Est.	Obs.
1701.4	9.6	δ
12.4	8.9	
17.4	9.1	
50.9	9.7	

035124
T Eridani

1701.4	10.0	δ
12.4	10.6	
17.4	10.9	
50.9	11.4	

041619
T Tauri

1818.9	11.2	M

042209
R Tauri

1689.3	9.1	Lt
1702.4	9.2	

042215
W Tauri

1809.9	11.0	V
11.8	10.8	M
18.8	11.0	

043065
T Camelop.

1686.4	8.9	Lt
1703.4	8.8	
24.4	8.1	
29	7.8	
40	7.3	
51.5	7.3	
53.4	7.7	L
61.5	7.6	Lt
76.7	8.2	Ba
77.4	8.5	L
90.4	9.1	
1811.8	9.7	M
38.5	10.3	Ba

043274
X Camelop.

1688.7	9.3	Lt
1749.5	11.4	
59.5	10.3	
76.7	8.4	Ba
82.6	8.6	Wh
1838.5	10.1	Ba

043263
R Reticuli

1700.5	8.6	δ
15.5	9.8	
18.4	10.0	
41.4	11.0	
80.8	12.4	

043562
R Doradus

J.D. 242	Est.	Obs.
1701.5	5.7	δ
15.5	5.8	
17.5	6.0	
43.4	5.7	
80.8	5.5	

043738
R Caeli

1701.5	12.3	δ

045514
R Leporis

1685.3	9.0	Lt

050022
T Leporis

1701.5	10.4	δ
17.5	11.2	

050849
UX Aurigae

1685.4	8.2	Lt

050953
R Aurigae

1685.4	12.9	Lt
1816.9	11.0	M

051247
T Pictoris

1700.5	11.9	δ
01.5	11.8	
15.5	13.1	
18.4	13.1	

052034
S Aurigae

1791.6	9.4	L
1816.9	8.8	M

053068
S Camelop.

1686	8.5	Lt
1709.4	8.5	
24.4	8.5	
29.4	8.4	
40.4	8.4	
51.5	8.5	
1834.6	9.6	Rd

053920
Y Tauri

1686.3	8.3	Lt
1703.4	8.0	

054319
SU Tauri

1686.4	9.2	Lt
91.3	9.5	
1810.6	9.7	L

054920
U Orionis

J.D. 242	Est.	Obs.
1694.3	9.5	Lt

055353
Z Aurigae

1689.4	10.4	Lt

055686
R Octantis

1699.7	7.3	δ
1715.5	7.5	
18.4	7.7	
41.4	8.2	
72.5	9.9	
89.8	9.9	

060450
X Aurigae

1689.3	8.8	Lt

060547
SS Aurigae

1682.5	10.9	Lt
86	12.3	

063558
S Lyncis

1748.4	9.8	Lt
61.4	10.1	

064030
X Gemin.

1685.4	12.8	Lt

065111
Y Monoc.

1693.4	10.7	Lt

065355
R Lyncis

1689.3	7.8	Lt
1704.4	7.9	
20.4	8.2	
29.4	8.5	
35.4	8.7	
44.4	9.0	
50.4	9.2	

070122a
R Gemin.

1685.4	12.1	Lt

071044
L^2 Puppis

1702.6	4.4	δ
06.4	4.5	
13.5	4.2	
17.5	4.1	
43.4	4.7	
72.5	5.7	

073723
S Gemin.

1685.4	12.6	Lt

074106
Nova Monoc.

J.D. 242	Est.	Obs.
1651.6	9.0	δ
59.6	9.1	
69.6	9.5	
82.5	9.5	
89.5	9.6	
99.5	9.9	
1709.4	10.2	
17.4	10.4	
29.4	10.8	
39.4	10.8	
45.4	10.9	

074323
T Gemin.

1685.4	9.1	Lt

074922
U Gemin.

1686.4	13.7	Lt

080322
RU Puppis

1719.4	8.3	δ
45.4	7.3	

081112
R Cancri

1689.3	6.8	Lt
1712.4	7.0	
24.4	7.1	
34.4	7.3	
49.4	7.6	

081617
V Cancri

1686.4	8.8	Lt
1712.4	8.0	
24.4	8.0	
49.4	8.3	

083350
X Urs. Maj.

1716.6	9.7	Ba

084803
S Hydrae

1693.4	10.8	Lt

085008
T Hydrae

1688.4	8.2	Lt
1712.4	7.7	
24.4	8.2	

085120
T Cancri

1753.4	9.1	L

090151
V Urs. Maj.

1719.4	10.7	Pe
29.3	10.7	
39.4	10.5	
47.3	10.4	

V Urs. Maj.

J.D. 242	Est.	Obs.
1753.3	10.3	
53.4	10.4	L
58.4	10.3	Pe
77.4	10.3	L
90.4	10.1	

091868
RW Carinae

1715.6	10.6	δ
18.7	10.1	
41.4	8.9	
72.5	9.1	
85.6	9.6	

092962
R Carinae

1699.7	7.1	δ
1715.6	8.0	
19.4	7.9	
41.4	8.9	
72.5	9.3	
85.6	9.7	

093178
Y Draconis

1717.6	13.5	Ba

093934
R Leo. Min.

1686.4	8.1	Lt
1704.4	9.0	
29.5	9.7	
36.4	10.0	
45.4	10.4	
49.4	10.6	

094023
RR Hydrae

1699.7	11.0	δ
1719.4	12.1	
15.4	12.9	
15.6	11.8	

094262
l Carinae

1772.4	4.1	δ
85.5	4.5	

094211
R Leonis

1689.3	8.5	Lt
1703.4	8.3	
14.4	7.3	
16.3	7.4	Pe
24.3	6.5	
24.4	6.5	Lt
29.3	5.7	Pe
30.4	6.1	Lt
34.4	6.0	
36.3	5.6	Pe
39.4	5.7	Lt
46.3	5.7	Pe
47	5.5	Lt
48.3	5.5	Pe

VARIABLE STAR OBSERVATIONS, July, Aug., Sept., 1918—Continued.

R Leonis

J.D. 242	Est.Obs.
1749.3	5.6 Pe
59.4	5.6 Lt
67.4	5.5 L
76.7	5.5 Pt

094622
Y Hydrae

1699.7	7.0 δ
1715.6	6.6
19.4	7.1
45.4	7.2
76.5	6.8

095421
V Leonis

1686.4	10.3 Lt
1716.3	10.9 Pe
24.3	11.2

100537
R Antliae

1772.5	7.7 δ

100661
S Carinae

1699.7	8.3 δ
1715.6	7.9
18.7	7.7
26.5	7.0
41.4	6.5
43.4	6.6
76.5	6.2
85.6	6.2

103212
U Hydrae

1689.3	5.3 Lt
94.3	5.3
99.7	5.7 δ
1702.7	5.7
13.5	5.7
17.5	5.8
19.4	5.7
26.4	5.3 Lt
43.5	5.4 δ
45.4	5.5
72.5	5.1
76.5	5.1

103769
R Urs. Maj.

1693.4	11.3 Lt
1704.4	10.4
20.4	8.7
30.4	7.7
39.4	7.4
48.4	7.4
49.3	7.6 Pe
50.3	7.4
57.5	7.4 Lt
63.4	7.3 Pe

R Urs. Maj.

J.D. 242	Est.Obs.
1776.7	7.7 M
79.6	7.9 Hu
83.7	8.0 Pt
95.7	7.9 B
1803.6	8.4 O
03.7	8.4 Pi
03.7	8.9 Pt
06.3	8.6 Pe
09.6	8.6 Ba
11.7	9.0 Pt
25.7	9.0 B
30.6	9.7 Ba

104620
V Hydrae

1715.6	7.8 δ
45.4	7.7
76.5	6.8

110361
RS Carinae

1778.5	15.0 δ

114441
X Centauri

1699.7	13.5 δ
1715.6	13.2
42.5	13.0
76 5	12.6
85.6	12.1

115919
R Comae

1741.4	8.6 Lt
49.4	8.5
56.5	8.5
77.6	8.6 Hu
77.6	8.2 Wh
82.6	7.9 Ba
90.6	8.4 B
1809.6	8.9 Ba

120012
SS Virginis

1802.6	12.2 Ba

121418
R Corvi

1685.4	11.1 Lt

122001
SS Virginis

1759.4	9.2 L
73.4	9.1
90.6	7.7 B
1802.6	7.2 Ba

122532
T Can. Ven.

1685.6	10.4 Lt
1750.4	12.5
82.6	11.2 Wh
1838.5	9.9 Ba

122803
Y Virginis

J.D. 242	Est.Obs.
1759.4	9.1 L
73.4	9.3

123160
T Urs. Maj.

1689.4	12.7 Lt
1741.4	10.0
46.5	9.2
47.4	8.7 Pe
56.5	8.7 Lt
57.4	8.3 Pe
63.4	8.2
76.7	9.1 M
82.6	8.5 Wh
82.7	8.6 Pt
1802.6	8.9 O
02.6	8.7 Ba
03.7	8.8 Pi
03.7	8.9 Pt
0 .3	8.8 Pe
04.7	8.6 B
06.4	8.9 Pe
11.7	9.0 Pt
23.7	9.1 Rd
25.7	9.5 B
30.6	9.8 Ba
31.6	9.7 M
38.6	10.1 O

123307
R Virginis

1689.4	10.3 Lt
1704.4	9.7
12.4	9.0
20.3	8.2 Pe
20.4	8.1 Lt
29.4	7.3
38.4	7.1
49.4	7.1
50.4	6.7 Pe
56.4	6.6
59.4	6 6 L
60.4	7.2 Lt
77.6	7.3 Wh
83.7	8.4 Pt
85.4	8.7 L

123459
RS Urs. Maj.

1789.7	14.5 M
1802.6	13.7 Ba

123961
S Urs. Maj.

1693.4	11.2 Lt
1708.4	9.6
24.4	8.8
30.4	8.7
38.4	8.7
46.4	8.7

S Urs. Maj

J.D. 242	Est.Obs.
1747.4	8.5 Pe
56.5	8.8 Lt
57.4	8.5 Pe
59.4	8.4 L
63.4	8.2 Pe
73.4	8.1 L
76.7	8.1 M
82.6	7.6 Ba
82.6	8.5 Wpi
82.7	8.3 Pt
85.4	8.7 L
85.7	7.1 V
95.7	7.8 B
96.4	8.2 L
1802.6	8.3 V
02.6	8.3 O
02.6	8.0 Ba
03.7	8.2 Pi
03.7	8.6 Pt
04.3	8.5 Pe
04.7	8.1 B
06.4	8.5 Pe
11.7	8.7 Pt
17.6	8.4 V
23.6	8.8 Rd
25.7	8.6 B
30.6	8.9 Ba
31.6	8.9 M
35.6	9.1 V
38.6	9.4 O

124045
Y Can. Ven.

1689.4	5.3 Lt
1724.4	5.4
30.4	5.5
47.5	5.5
60.4	5.5

124204
RU Virginis

1685.4	11.9 Lt
1778.7	13.2 B

124606
U Virginis

1724.3	11.5 Pe
51.4	9.7
51.5	9.6 Lt
52.4	9.5 Pe
77.6	8.5 Wh
82.7	8.8 Pt
90.6	8.1 B
1802.6	8.4 Ba

131283
U Octantis

1699.7	12.1 δ
1715.6	12.7
42.5	13.5
76.5	13.5
80.7	13.4

131546
V Can. Ven.

J.D. 242	Est.Obs.
1685.4	7.0 Lt
1703.4	7.1
27.4	7.2
39.4	7.5
47.5	7.7
60.4	8.4

132202
V Virginis

1689.5	10.0 Lt
1702.4	8.8
24.4	9.1
47.5	9.6

132422
R Hydrae

1689.4	8.6 Lt
1715.6	7.7 δ
16.4	8.4 Pe
24.4	7.6 Lt
38.5	7.5
45.4	7.4 δ
51.4	7.2 Pe
53.4	6.7 L
67.4	6.2
76.5	7.1 δ
83.4	6.3 L
85.6	6.5 δ

132706
S Virginis

1685.4	9.2 Lt
1724.4	9.4
49.4	10.3
73.4	11.7 L

133273
T Urs. Min.

1686.4	9.4 Lt
1703.4	9.3
29.4	9.8
44.4	10.6
50.5	11.0
60.5	11.4
1802.6	12.5 Ba
30.6	12.8

133633
T Centauri

1765.5	6.8 δ
85.6	6.2

134236
RT Centauri

1715.6	9.3 δ
43.4	10.7
76.5	12.8
85.6	13.0

134440
R Can. Ven.

1685.4	11.5 Lt
1746.5	10.3

VARIABLE STAR OBSERVATIONS, July, Aug., Sept., 1918—Continued.

R Can. Ven.

J.D. 242	Est.	Obs.
1760.4	10.2	Lt
76.8	10.0	M
82.6	10.0	Wh
91.6	9.3	B
1828.6	8.3	B
31.6	8.5	M
35.7	8.0	Pt
38.5	7.9	Ba

134677
T Apodis

1776.5	8.6	δ

140113
Z Bootis

1689.4	9.4	Lt
1728.4	9.9	
49.4	10.7	
77.6	9.7	Hu
1802.6	13.4	Ba

140512
Z Virginis

1787.6	12.5	B

140959
R Centauri

1743.4	10.3	δ
72.5	9.4	
76.6	9.2	
85.6	8.9	

141567
U Urs. Min.

1689.4	11.7	Lt
1747.5	10.1	
88.7	9.4	M
93.7	8.9	B
1828.6	7.6	B
31.6	8.2	M
38.5	7.6	Ba

141954
S Bootis

1688.4	11.4	Lt
1782.6	12.4	Wh
90.7	12.7	B
1808.4	12.0	L
33.6	9.8	B
38.5	9.7	Ba

142205
RS Virginis

1689.4	8.6	Lt
1704.5	8.0	
30.4	8.1	
39.4	8.1	
49.5	8.1	
1802.6	9.8	Ba

142584
R Camelop.

J.D. 242	Est.	Obs
1686.4	13.3	Lt
1748.5	11.3	
53.5	10.8	
58.4	10.3	
79.6	9.0	Hu
1802.7	8.8	B
28.6	8.3	B
38.6	8.2	Ba
38.6	8.2	O

142539
V Bootis

1689.4	9.7	Lt
1703.4	9.7	
25.4	9.9	
47.5	10.1	
53.5	10.1	
59.4	9.4	L
60.4	10.0	Lt
73.4	9.2	L
77.6	8.9	Hu
77.7	8.4	M
82.6	8.6	Wh
82.7	9.2	Pt
85.4	8.8	L
91.8	8.3	Mu
1800.4	8.2	L
02.6	8.0	O
03.7	8.1	Pi
04.7	7.9	B
06.7	7.8	Pt
11.7	7.8	Pt
12.7	7.5	Mu
25.6	7.7	B
31.6	7.5	M
38.5	7.4	Ba

143227
R Bootis

1689.4	7.7	Lt
1703.4	7.5	
12.4	7.5	
24.4	7.7	
28.4	7.8	
39.4	8.3	
49.5	9.0	
60.4	9.7	
77.6	11.6	Hu
77.7	11.0	M
82.6	11.3	Wh
95.6	11.7	B
1802.6	12.2	Ba
11.6	11.3	M
30.6	12.3	Ba

144918
U Bootis

1777.7	11.5	M
1802.6	11.3	Ba
23.6	11.0	B
30.6	10.4	Ba

145254
Y Lupi

J.D. 242	Est.	Obs.
1705.9	13.8	δ
43.5	14.0	
76.6	14.0	

151520
S Librae

1777.4	10.9	L
85.4	10.4	
1806.4	9.6	

151744
S Serpentis

1686.5	13.1	Lt
1749.4	11.2	
59.4	11.2	L
73.4	10.9	
82.6	10.0	Wh
83.4	10.0	L
1804.4	8.4	
38.6	8.3	Ba

151731
S Cor. Bor.

1686.4	8.8	Lt
1704.4	9.3	
24.3	9.8	Pe
29.4	10.0	Lt
50.4	10.3	
77.7	11.1	M
79.6	10.4	Hu
79.7	11.3	Wh
1802.6	12.1	Ba
04.7	12.0	B
30.6	12.4	Ba

151822
RS Librae

1745.5	11.2	δ
73.4	12.0	L
76.6	11.0	δ
78.7	11.6	B
1833.6	9.7	

152849
R Normae

1705.3	13.2	δ
44	10.9	
61.8	10.3	
76.6	9.0	

153378
S Urs. Min.

1686.4	9.6	Lt
1703.4	9,7	
24.4	10.3	
50	11.0	
79.6	10.3	Hu
93.7	10.6	B
1838.5	10.5	Ba

153654
T Normae

J.D. 242	Est.	Obs.
1705.9	13.0	δ
45.5	11.1	
61.8	7.7	
76.6	6.6	

154428
R Cor. Bor.

1688.4	8.4	Lt
94.3	8.6	
1703.4	8.4	
12.4	8.5	
19.3	7.8	Pe
20.4	8.0	Lt
30.3	7.6	Pe
30.4	7.8	Lt
39.4	7.6	
46.3	7.5	Pe
48.4	7.4	Lt
53.4	7.4	L
53.4	7.4	Pe
58.4	7.4	
59.4	7.3	L
60.4	7.4	Lt
65.4	7.4	L
72.4	7.2	
75.4	7.1	Pe
75.6	6.9	Ba
76.6	6.9	
76.7	7.1	M
76.7	7.4	Pt
77.6	6.8	Ba
77.6	7.3	Wh
77.7	7.3	Pt
78.4	7.1	L
79.6	7.0	Hu
79.7	6.9	Wh
80.3	6.9	Pe
80.7	7.0	Pt
81.7	7.0	
82.6	7.0	Ba
82.7	6.9	Pt
82.8	7.3	Go
83.4	7.1	L
83.7	6.9	Pt
83.7	6.8	B
85.4	7.0	L
85.7	7.0	V
85.7	6.7	Pt
86.3	6.8	Pe
86.7	6.7	Pt
87.4	6.9	L
87.7	6.7	Pt
87.7	6.5	M
88.5	6.9	L
88.7	6.8	Pt
89.7	6.7	
90.4	6.8	L
92.6	6.8	
93.8	7.0	Mu
94.7	6.7	Pt

R Cor. Bor.

J.D. 242	Est.	Obs.
1794.8	7.0	Mu
95.7	6.6	Pt
96.4	6.9	L
99.7	6.8	Mu
1800.3	6.8	L
01.7	6.6	Pt
02.3	6.8	L
02.6	7.0	V
02.6	6.8	O
02.6	6.9	Ba
02.7	6.5	Pt
03.3	6.6	L
03.6	6.9	O
03.7	7.2	Pi
03.7	6.6	Pt
04.4	6.7	L
04.6	6.8	Wh
04.7	6.8	Pt
05.3	6.8	Pe
05.7	6.6	Pt
06.3	6.8	L
06.7	6.5	Pt
07.6	6.9	O
07.7	6.8	Pt
07.7	7.0	Mu
08.4	6.8	L
08.7	6.7	Pt
08.7	7.0	Mu
09.6	7.0	Ba
09.7	7.0	Rd
09.5	7.0	Mu
09.7	6.8	Pt
10.6	6.5	V
10.7	6.9	Pt
10.7	7.0	Mu
11.7	6.9	Pt
11.7	7.0	Mu
12.6	7.0	V
12.7	7.0	Mu
13.7	7.6	Pt
14.7	6.8	
14.7	7.0	Mu
15.1	7.1	My
15.6	6.6	Wh
15.7	6.7	Pt
15.8	7.0	Mu
17.6	7.1	V
17.7	6.8	Pt
17.8	7.0	Mu
18.7	6.7	Pt
18.7	7.1	Mu
19.7	7.1	Pt
20.7	6.8	
21.6	7.0	Rd
23.6	6.9	
24.7	6.9	Pt
25.7	6.6	
26.7	6.8	
28.7	6.5	
29.7	6.4	
29.7	7.0	Mu

VARIABLE STAR OBSERVATIONS, July, Aug., Sept., 1918—Continued.

R Cor. Bor.

J.D. 242	Est.	Obs.
30.5	6.8	Ba
31.6	6.3	M
32.5	6.9	Ba
32.6	6.6	Wh
33.5	6.9	Ba
34	7.1	My
34.6	6.9	O
34.6	6.9	Rd
34.7	7.1	Mu
35.6	7.0	V
35.7	6.6	Pt
37.7	6.7	
38.5	6.8	Ba
38.6	6.9	Rd
39.6	6.9	

154536
X Cor. Bor.

1689.5	11.7	Lt
1727.4	9.5	
46.4	9.3	
60.4	9.2	
76.8	9.7	M
79.7	9.0	Wh
85.7	9.3	V
1802.6	10.2	V
02.6	10.6	Ba
02.7	10.5	B
17.6	11.5	V
25.6	11.9	B
30.6	12.3	Ba
31.6	10.3	M

154639
V Cor. Bor.

1686.4	9.7	Lt
1703.4	9.8	
29.4	10.3	
49.5	10.8	
76.8	11.0	M
1802.6	8.5	Ba
30.6	7.8	
31.6	9.3	M

154615
R Serpentis

1689.4	6.6	Lt
1704.4	7.3	
12.5	7.4	
19.3	8.1	Pe
24.4	8.0	Lt
29.3	8.1	Pe
32.4	8.1	Lt
39.4	8.4	
47.5	8.6	

R Serpentis

J.D. 242	Est.	Obs.
50.3	8.4	Pe
60.4	8.9	Lt
77.7	8.9	M
82.6	9.8	Wh
85.7	9.7	V
1802.6	10.5	V
02.7	11.0	B
03.7	11.2	Pi
05.3	11.0	Pe
07.6	11.0	O
38.6	12.6	Ba

154749
ST Herculis

1686.4	8.0	Lt

154736
R Lupi

1745.5	8.8	δ
61.8	9.6	
76.6	10.1	

155229
Z Cor. Bor.

1685.5	10.9	Lt
1719.5	12.6	
87.7	14.0	B

155847
X Herculis

1689.4	7.1	Lt
1704.4	7.1	
22.4	7.0	
29.3	6.8	Pe
31.4	7.1	
49.4	6.9	
58.5	7.1	
78.7	6.7	Mu
90.7	6.9	
98.7	6.6	
1810.7	6.2	
17.7	6.0	
31.7	6.0	
35.8	6.1	

155823
RZ Scorpii

1838.6	11.0	Ba

160150
RR Herculis

1686.4	9.0	Lt
1753.4	8.9	

160210
U Serpentis

1693.4	10.7	Lt
1751.4	12.4	
83.6	12.5	

U Serpentis

J.D. 242	Est.	Obs.
1802.6	11.6	Ba
07.6	11.5	O
30.6	10.6	Ba
33.6	10.1	B

160325
SX Herculis

1690.6	8.2	Lt
1704.4	8.3	
24.4	8.7	
34.4	8.7	
46.4	8.4	

160625
RU Herculis

1782.7	11.8	Wh
1802.6	13.3	Ba
03.6	14.2	M

161122
T Scorpii

1838.6	10.8	Ba

161122b
S Scorpii

1748.4	9.4	Lt
56.5	9.4	
1838.6	12.4	Ba

161138
W Cor. Bor.

1749.5	10.9	Lt
60.4	10.6	
76.8	9.5	M
77.6	9.6	Ba
79.7	9.4	Wh
1802.6	9.4	Ba
02.7	9.1	B
25.7	9.2	B
30.6	9.5	Ba

161607
W Ophiuchi

1783.6	11.7	M
1823.6	11.1	B
38.6	9.8	Ba

162112
V Ophiuchi

1694.6	9.6	Lt
1750.5	8.4	
61.4	8.1	
79.7	7.4	Wh
83.6	8.4	M
87.6	7.4	B
1815.6	7.4	Wh
23.6	7.2	B
38.6	7.6	Ba

162119
U Herculis

J.D. 242	Est.	Obs
1686.5	13.1	Lt
1748.4	10.5	Pe
50.4	11.3	Lt
58.4	11.3	
59.4	10.7	Pe
76.8	10.2	M
80.6	10.0	Hu
82.6	10.4	Wh
85.7	10.2	V
96.8	8.3	Go
1802.6	9.7	V
03.6	10.0	O
03.7	9.6	Pi
05.3	9.7	Pe
06.7	9.8	Pt
12.8	9.6	Mu
17.6	8.9	V
35.7	8.0	Pt
37.6	8.0	V
38.6	7.6	Ba
39.6	8.0	O

162542
g Herculis

1689.4	5.3	Lt
1703.4	5.3	
29.3	5.1	Pe
31.4	5.3	Lt
39.4	5.2	
49.4	4.9	
58.4	4.8	
78.7	4.7	Mu
90.7	4.9	
98.7	4.8	
1810.7	5.1	
17.7	4.8	
31.7	4.7	
35.8	4.6	

162807
SS Herculis

1688.5	10.6	Lt
1717.6	10.9	Ba
49.5	12.1	Lt
59.5	11.9	
79.7	11.0	Wh
82.7	10.3	M
1802.6	9.8	Ba
08.7	9.9	B
09 6	9.4	Ba
21.6	9.8	Wh
30.5	10.1	Ba
32.5	10.5	
38.5	10.7	
39.6	11.1	O

162816
S Ophiuchi

1777.6	13.3	Ba

163172
R Urs. Min.

J.D. 242	Est.	Obs.
1686.4	9.4	Lt
1753.5	9.5	
82.7	9.9	M
1818.6	9.0	B
19.7	9.4	M
38.6	9.5	Ba

163137
W Herculis

1749.5	9.3	Lt
76.8	8.0	M
80.6	7.9	Hu
85.7	8.1	V
1802.7	8.2	
17.7	8.8	
19.7	9.1	M
21.7	8.8	B
34.7	9.2	
37.6	9.7	V
38.6	9.2	Ba

163266
R Draconis

1689.5	8.3	Lt
1703.4	8.3	
12.5	8.7	
28.4	9.5	
35.4	9.8	
47.5	10.2	
60.4	11.2	
77.7	11.7	Wh
82.7	11.9	M
1819.7	12.4	M
38.6	12.5	Ba

164055
S Draconis

1778.7	7.8	M
1806.7	9.1	Pt
07.7	8.6	M
35.7	8.8	Pt
38.6	8.5	Ba

164319
RR Ophiuchi

1779.6	8.4	Wh
87.7	8.5	B
1807.6	7.8	Wh
23.6	8.3	B
38.6	8.6	Ba

164715
S Herculis

1688.5	12.0	Lt
1749.5	11.0	
60.4	10.3	
82.6	9.3	Wh
83.6	9.2	M
1835.7	9.1	Pt
38.6	8.2	Ba

VARIABLE STAR OBSERVATIONS, July, Aug., Sept., 1918—Continued.

164844
RS Scorpii

J.D. 242	Est.	Obs.
1745.5	7.9	δ
61.8	8.7	
76.6	10.0	

165030
RR Scorpii

1699.7	6.4	δ
1702.7	6.3	
05.6	6.8	
15.6	6.8	
18.7	6.9	
27.5	7.2	
45.5	7.4	
50.9	7.2	
61.8	7.6	
76.6	8.2	
85.6	9.0	

165202
SS Ophiuchi

1782.7	11.7	M
1835.6	8.6	Ba

165631
RV Herculis

1730.3	10.2	Pe
45.3	10.7	
47.4	11.4	Lt
57.4	11.0	
76.8	11.7	M
77.6	11.4	Ba
80.6	11.3	Hu
1802.6	13.6	Ba
03.6	13.0	M
30.6	13.6	Ba

170215
R Ophiuchi

1779.6	12.0	Wh
1807.6	9.6	Wh
35.7	8.8	Pt
38.6	8.5	Ba

171401
Z Ophiuchi

1782.7	9.3	M
85.7	9.1	V
87.7	9.4	B
1805.6	10.0	V
09.6	9.9	B
17.7	10.4	V
38.6	11.2	Ba

171723
RS Herculis

1685.5	9.6	Lt
48.5	12.4	
50.3	12.3	
77.6	12.3	
80.6	12.2	Hu
83.7	1.24	M

RS Herculis

J.D. 242	Est.	Obs.
1802.6	9.7	Ba
21.6	9.1	B
24.6	8.7	Bu
30.6	8.8	Ba
34.7	8.5	B

172486
S Octantis

1699.7	13.0	δ
1715.6	13.2	
18.4	13.1	
41.4	13.0	
72.5	11.5	
80.7	10.8	

172809
RU Ophiuchi

1777.6	10.8	Ba
78.7	10.3	B
83.7	10.1	M
1802.7	9.3	B
24.6	9.6	Bu
25.6	9.9	B
30.6	9.9	Ba

173457
TY Draconis

1720.2	9.2	Pe
29.3	9.2	
46.4	9.0	

175111
RT Ophiuchi

1776.6	9.6	Ba
79.7	10.3	Wh
82.7	10.2	M
87.7	10.5	B
1812.7	11.0	B
21.6	11.4	Wh
27.6	11.5	B
30.6	11.8	Ba

175458
UY Draconis

1838.6	11.0	Ba

175458
T Draconis

1838.6	12.2	Ba

175519
RY Herculis

1686.5	12.3	Lt
45.4	8.9	Pe
47.4	8.8	Lt
49.4	8.8	Pe
53.4	9.1	
57.4	8.9	Lt
59.4	9.3	Pe
76.8	9.6	M
1821.6	13.1	B
34.7	13.5	B
38.6	13.6	Ba

175654
V Draconis

J.D. 242	Est.	Obs.
1824.6	11.2	Bu
38.6	13.5	Ba

180363
R Pavonis

1745.5	8.3	δ
61.8	8.3	
80.6	8.2	

180531
T Herculis

1688.5	8.7	Lt
1703.4	8.1	
12.4	7.8	
16.3	7.2	Pe
24.3	8.2	
24.4	7.7	Lt
29.3	8.4	Pe
30.4	8.1	Lt
39.4	8.4	
48.4	9.4	Pe
49.5	9.5	Lt
58.4	10.8	Pe
59.4	10.6	L
60.4	10.8	Lt
73.4	12.0	L
76.8	10.2	M
80.6	11.9	Hu
83.4	12.4	L
85.8	10.4	V
96.8	9.0	Go
1806.4	12.4	L
21.7	11.8	B
34.7	10.5	B
38.6	11.0	O
38.6	10.7	Ba

180666
X Draconis

1809.6	11.5	Ba
30.6	10.9	

181031
TV Herculis

1750.4	12.2	Pe
53.4	12.4	
58.4	12.5	
73.4	12.5	L
77.4	11.8	
83.4	10.7	
89.6	10.4	
92.5	9.5	L
1806.4	9.6	Pe
08.4	9.1	L

181136
W Lyrae

1694.6	8.0	Lt
1704.4	8.6	
20.4	9.2	
34.4	9.8	Lt

W Lyrae

J.D. 242	Est.	Obs.
1744.4	9.9	Lt
47.3	9.9	Pe
49.5	10.1	Lt
83.6	11.4	M
93.7	11.0	Mu
95.6	12.3	B
1820.6	10.0	M
38.6	9.0	Ba

181103
RY Ophiuchi

1750.5	9.2	Lt
61.5	9.4	
79.7	11.7	Wh
88.7	12.2	M
90.6	12.0	B
1812.6	12.0	
21.6	12.2	Wh
38.6	12 0	Ba

182133
RV Sagittarii

1745.5	10.5	δ
61.8	11.7	
80.6	12.4	

182224
SV Herculis

1749.4	10.8	Lt
57.4	10.1	
77.4	9.6	L
88.8	10.3	M
90.4	9.8	L
1809.6	11.5	Ba
21.7	12.0	B
30.5	11.6	De
30.6	12.6	Ba
34.7	13.1	B

182306
T Serpentis

1689.6	11.1	Lt
1724.5	9.1	
50.5	10.0	
58.5	10.5	
88.8	12.1	M

183225
RZ Herculis

1749.4	12.3	Lt
57.4	11.2	
1809.6	11.2	Ba
30.6	12.0	Ba

183308
X Ophiuchi

1689.6	8.1	Lt
1704.5	8.1	
24.4	8.1	
34.5	8.0	
49.5	7.8	

X Ophiuchi

J.D. 242	Est.	Obs.
1759.4	7.2	L
73.4	6.6	
79.7	6.9	Wh
87.6	6.9	B
88.7	6.2	M
90.4	6.1	L
1809.7	6.7	B
21.6	6.7	Wh
27.6	7.0	B
28.6	6.8	Ba

184243
RW Lyrae

1803.6	14.0	M

184205
R Scuti

1689.6	5.9	Lt
1702.7	5.6	δ
03.5	5.9	Lt
05.9	5.3	δ
18.7	5.6	δ
20.5	5.1	Lt
33.4	5.5	
39.4	5.8	
45.4	5.7	Pe
49.4	5.9	Lt
50.9	5.7	δ
52.4	5.8	Pe
57.4	5.8	
58.4	5.9	
58.4	6.1	Lt
59.4	5.8	L
61.5	6.0	
61.8	6.0	δ
63.4	6.0	Pe
67.4	6.4	L
69.4	6.4	
71.4	6.3	
72.3	6.6	Pe
73.4	6.5	L
74.3	6.8	Pe
75.3	6.7	
76.3	6.8	
76.6	6.7	Ba
76.7	6.5	Pt
76.8	6.2	Go
76.8	6.9	M
77.4	6.7	L
77.6	6.8	Ba
77.7	6.8	Wh
77.7	7.1	Pt
79.6	6.8	L
79.8	6.0	Go
80.3	7.1	Pe
80.7	7.3	Pt
80.7	7.2	δ
81.3	7.1	Pe
81.7	7.5	M
82.3	7.2	Pe

VARIABLE STAR OBSERVATIONS, July, Aug., Sept., 1918—Continued.

R Scuti			R Scuti			Nova Aquilae No. 3			Nova Aquilae No. 3			Nova Aquilae No. 3		
J.D. 242	Est.	Obs.	J.D. 242	Est.	Obs.	J.D. 242	Est.	Obs.	J.D. 242	Est.	Obs.	J.D. 242	Est.	Obs.
1782.6	7.2	Ba	1714.7	6.5	Pt	1770.3	2.7	Pe	1779.6	3.0	Me	1787.7	4.0	Pt
82.7	7.4	Pt	14.7	6.3	Mu	70.4	3.2	L	79.7	3.2	J	87.7	4.0	Y
83.4	7.1	L	15.5	6.2	My	70.5	3.2	Lt	79.7	3.2	Y	87.7	4.0	Mu
83.7	7.3	Pt	15.7	6.4	Pt	70.6	3.5	δ	80.3	3.3	Pe	87.7	3.8	M
85.4	7.4	L	15.8	6.5	Mu	71.3	3.3	Pe	80.4	3.3	L	88.5	3.9	L
85.7	7.4	Pt	17.7	6.5	Pt	71.3	3.4	L	80.6	3.3	δ	88.7	3.9	Pt
86.3	7.3	Pe	17.8	6.6	Mu	71.5	3.4	Lt	80.6	3.1	Me	88.8	3.5	Go
86.7	7.4	Pt	18.7	6.4	Pt	71.7	3.2	Pt	80.7	3.3	Wh	89.5	3.8	L
87.4	7.7	L	19.7	6.6		72.3	3.6	Pe	80.7	3.3	Y	89.6	3.8	M
87.7	7.6	Pt	19.7	6.6	Mu	72.3	3.9	L	80.7	3.1	Pt	89 6	3.5	Me
88.5	7.6	L	20.7	6.5	Pt	72.5	4.0	δ	81.3	3.3	Pe	89.6	3.6	V
88.7	7.6	M	21.6	6.7	Wh	73.3	3.8	L	81.4	3.3	Lt	89.6	3.7	O
88.7	7.6	Pt	23.6	5.9	Rd	73.4	3.8	Lt	81.6	3.2	Me	89.6	3.9	B
88.8	6.5	Go	23.6	5.8	Bu	74.3	3.8	Y	81.7	3.3	J	89.7	3.7	Pt
89.6	7.3	L	24.7	5.9	Pt	74.3	3.7	Pe	81.7	3.1	Pt	89.7	3.6	Pi
89.7	7.9	Pt	25.7	5.7		74.4	4.0	Lt	81.7	3.3	M	89.7	3.6	Mu
90.4	7.5	L	26.7	5.4		74.7	3.5	Y	81.9	3.4	Mu	89.7	3.8	Fa
91.6	7.2		28.7	5.4	Pt	74.7	3.9	Pt	82.3	3.4	Pe	90.3	3.7	L
92.6	7.1		29.7	5.6		75.3	3.6	Pe	82.8	3.6	L	90.4	3.8	Lt
93.8	7.4	Mu	29.7	6.3	Mu	75.4	3.7	Lt	82.4	3.4	Lt	90.6	3.5	B
94.6	7.1	L	30.5	5.9	Ba	75.6	3.5	Ba	82.6	3.4	Ba	90.6	3.8	O
94.7	7.7	Pt	30.7	6.0	Mu	75.7	3.3	Pt	82.6	3.4	Me	90.6	3.6	Me
94.8	7.4	Mu	32.5	5.5	Ba	75.7	3.4	Y	82.7	3.2	Pi	90.6	3.7	Fa
95.7	7.8	Pt	34.7	5.9	Mu	76.3	3.5	Pe	82.7	3.5	Y	90.6	3.6	De
96.4	7.1	L	35.7	5.3	Pt	76.3	3.3	L	82.6	3.6	M	90.7	3.9	J
99.7	7.3	Mu	35.8	5.9	Mu	76.4	3.2	Lt	82.7	3.2	Pt	90.7	3.8	M
1800.4	6.9	L	37.7	5.2	Pt	76.6	3.4	δ	82.8	3.3	Go	91.5	3.9	L
00.7	7.4	Mu	38.5	5.4	Ba	76.6	3.4	Ba	83 3	3.6	L	91.4	3.5	Lt
01.3	7.1	Pe	38.6	5.5	O	76.6	3.0	Me	83.4	3.4	Lt	91.6	3.5	B
01.7	7.3	Mu	39.6	5.5	O	76.6	3.3	Wh	83.6	3.2	Me	91.6	3.6	Me
01.7	7.4	Pt				76.7	3.3	J	83.6	3.5	B	91.7	3.7	Fa
02.7	7.5					76.7	3.2	Pi	83.6	3.7	M	91,7	3.9	Mu
03.4	6.7	L				76.7	3.2	Y	83.7	3.4	J	92.5	3.8	L
03.6	6.8	O	184300			76.7	3.6	Mu	83.7	3.6	Fa	92.6	3.7	De
03.7	7.3	Pt	NovaAquilae			76.7	3.2	M	83.7	3.5	Y	92.7	3.9	Y
03.7	7.3	Mu	No. 3			77.7	3.3	Pt	83.7	3.2	Pt	92.7	3.9	M
04.3	6.8	Pe	1753.4	1.0	Lt	77.3	3.3	L	84.4	3.6	Lt	93.4	3.8	Lt
04.4	6.8	L	53.7	0.1	Pt	77.3	3.3	Pe	84.7	3.7	M	93.6	3.7	Fa
05.7	7.4	Pt	56.4	0.4		77.4	3.2	L	85.3	3.6	L	93.6	3.6	B
06.7	7.2		57.4	0.8	Pe	77.6	3.2	Ba	85.4	3.9	Lt	93.8	4.0	Mu
07.6	6.9		57.5	0.6	Lt	77.6	3.1	Me	85.6	3.7	δ	94.3	3.8	Pe
07.6	6.9	O	58.4	0.8	Pe	77.6	3.2	De	85.6	4.0		94.4	4.0	Lt
07.6	6.6	B	58.4	1.0	Lt	77.6	3.1	B	85.6	3.7	Fa	94.5	3.9	L
07.7	7.3	Mu	59.3	0.9	L	77.7	3.0	Pi	85.7	4.0	Pt	94.6	4.0	Rd
08.4	6.5	L	59.4	1.0	Pe	77.7	3.3	Wh	85.7	3.7	V	94.7	4.0	Pt
08.5	5.9	My	60.4	1.3	Lt	77.7	3.4	Mu	86.3	3.6	Pe	94.8	4.0	Mu
08.7	6.2	Pt	61.5	1.9	L	77.7	3.0	Pt	86.4	3.8	L	95.6	4.2	B
08.7	7.0	Mu	61.5	1.8	Lt	77.7	3.1	M	86.6	3.6	Wh	95.7	4.3	Pt
09.6	6.5	Ba	61.8	1.9	δ	78.5	3.0	δ	86.7	4.0	Pt	95.7	3.7	J
09.7	6.8	Pt	63.4	2.3	Pe	78.6	3.2	B	86.7	4.0	Mu	95.7	4.0	Mu
09.8	6.9	Mu	63.4	1.9	Lt	78.6	3.0	Me	86.7	3.8	Fa	96.3	4.3	L
10.5	6.1	My	64.4	2.3		78.7	3.3	Y	86.7	3.9	Y	96.8	3.7	Go
10.7	6.8	Pt	66.3	2.4	L	78.7	3.4	Mu	87.3	4.1	L	99.3	3.8	Pe
10.7	6.8	Mu	67.3	2.5		78.7	3.0	M	87.4	4.0	Lt	99.7	4.0	Mu
11.7	6.9		67.4	2.5	Lt	78.7	3.2	Rd	87.6	4.0	B	1800.3	4.0	L
11.7	6.6	Pt	68.4	2.8		79.4	3.1	Lt	87.6	3.9	Wh	00.6	3.9	Me
12.7	6.5	Mu	69.3	2.8		79.5	3.2	L	87.6	3.9	V	00.7	4.0	Mu
13.7	6.8	Pt	69.4	3.0		79.6	3.3	B	87.7	3.2	Rd	01,3	3.8	Pe
14.5	6.1	My	69.6	3.0	Rd	79.6	3.1	De	87.7	3.8	Fa	01.6	3.8	Me

VARIABLE STAR OBSERVATIONS, July, Aug., Sept., 1918—Continued.

Nova Aquilae No. 3

J.D. 242	Est.	Obs.
1801.7	4.1	Mu
01.9	3.9	Pi
02.3	4.0	L
02.5	3.7	Ba
02.6	3.8	B
02.6	3.8	O
02.6	3.9	V
02.6	3.7	Fa
02.6	3.9	Me
02.7	3.9	Y
02.7	4.0	J
02.7	4.1	Mu
02.7	3.8	Pt
02.8	3.9	Pi
03.4	4.0	L
03.6	3.8	M
03.6	3.9	B
03.6	3.8	O
03.6	4.1	Rd
03.7	3.8	Pt
03.7	4.0	J
03.7	4.0	Mu
03.7	3.7	Pi
03.7	3.8	Y
04.3	3.8	Pe
04.4	4.1	L
04.6	3.9	B
04.6	4.0	Me
04.7	3.8	Y
04.7	3.7	Fa
05.3	3.8	Pe
05.6	4.3	V
05.6	3.9	Wh
05.7	4.0	Pt
05.7	3.9	Y
06.3	3.8	Pe
06.3	4.1	L
06.7	4.2	J
06.7	3.9	Pt
06.7	3.9	Y
07.6	4.6	B
07.6	4.4	Wh
07.6	4.3	O
07.6	4.3	J
07.6	4.3	Y
07.6	4.6	Fa
07.6	4.8	De
07.7	4.6	Mu
07.7	4.5	Pi
07.7	4.6	Re
07.7	4.2	Pt
08.3	4.6	L
08.5	4.3	My
08.6	4.5	Re
08.6	4.6	B
08.7	4.4	Pt
08.7	4.7	Mu
08.8	4.0	Go
09.5	4.5	Ba

Nova Aquilae No. 3

J.D. 242	Est.	Obs.
1809.6	4.7	V
09.6	4.9	Me
09.6	4.8	B
09.6	4.7	Rd
09.6	4.4	Y
09.7	4.6	Re
09.7	4.4	Pt
09.8	4.8	Mu
10.4	4.7	L
10.6	4.8	V
10.6	4.8	Me
10 7	4.9	Mu
10.7	4.2	Y
10.7	4.5	Pt
11.6	4.5	J
11.6	4.6	Fa
11.6	4.8	Me
11.7	5.0	Mu
11.7	4.5	Pt
11.7	4.6	Re
12.6	4.1	B
12.6	4.0	M
12.6	3.8	Fa
12 6	4.3	Me
12.6	4.3	V
12.7	3.9	Mu
12.7	4.0	Re
12.7	4.1	Pt
13.6	3.8	Y
13.7	4.0	Pt
13.7	4.0	Re
14.5	4.0	My
14.6	4.0	B
14.6	4.2	J
14.6	3.8	Fa
14.6	4.3	Me
14.7	4.0	Pt
14.7	3.9	Mu
15.5	4.1	My
15.6	4.3	Wh
15.6	4.2	J
15.7	4.2	Pt
15.8	4.1	Mu
16.7	3.8	Y
16.8	4.4	M
17.5	4.5	My
17.6	4.4	V
17.7	4.1	Pt
17.8	4.0	Mu
18.6	4.3	B
18.6	4.2	J
18.6	4.0	Y
18.7	4.2	Mu
18.7	4.4	Pt
18.7	4.4	M
19.6	4.6	Re
19.6	4.0	Y
19.6	4.6	Fa
19.6	4.7	B

Nova Aquilae No. 3

J.D. 242	Est.	Obs.
1819.6	4.7	V
19.7	4.7	Mu
19.7	4.7	Pt
19.7	4.4	M
20.6	4.6	Re
20.7	4.1	Y
20.7	4.4	M
20.7	4.5	Pt
21.6	4.8	Me
21.9	4.7	J
21.6	4.8	Wh
21.6	4.9	B
21.6	4.7	O
21.6	4.5	M
21.6	4.8	Rd
21.6	4.7	Fa
21.7	4.6	Re
22.5	4.6	My
22.6	4.4	J
22.6	4.7	Me
23.5	4.6	My
23.6	4.4	B
23.6	4.4	J
23.6	4 5	Rd
24.5	4.4	My
24.6	4.6	Wh
24.6	4.5	B
24.6	4.8	Bu
24.7	4.3	Pt
25.6	4 8	B
25.6	4.4	J
25.7	4.5	Pt
27.5	4.4	My
27.6	4.8	B
28.6	4.8	J
28.6	4.9	B
28.7	4.8	Pt
29.6	4.8	J
29.7	5.0	Mu
30.5	4.9	Ba
30.6	4.6	Wh
30.6	4.7	J
30.6	4.8	Me
30.7	4.9	Mu
31.6	4.3	Y
31.6	4.8	Me
31.6	4.9	B
31.6	4.6	O
31.6	4.7	M
31.6	4.9	
31.7	3.8	Go
32.5	4.2	Ba
32.6	4.4	B
32.6	4.7	Me
33.5	4.0	Ba
33.6	4.7	B
33.6	4.6	Wh
33.6	5.1	Rd
33.7	4.3	Fa

Nova Aquilae No. 3

J. D. 242	Est.	Obs.
1833.7	4.7	Re
34.4	4.4	My
34.6	4.6	B
34.6	4.2	O
34.6	4.7	Rd
34.6	4,3	Fa
34.7	4.8	Mu
35.6	4.5	Pe
35.6	4.3	
35.6	4.0	J
35.6	4.8	Me
35.6	4.7	V
35.7	4.5	Pt
35.8	4.2	Mu
36.6	4.9	Me
36.6	4.3	J
37.6	4.6	O
37.6	4.5	Y
37.6	4.9	V
37.7	4.9	Pt
38.5	5.0	Ba
38.6	4.6	
38.6	4.7	J
39.6	4.6	
43.7	4.6	O

185032
RX Lyrae

1789.6	15.3	M

185243
R Lyrae

1689.5	4.2	Lt
1703.4	4.2	
12.5	4.3	
24	4.3	
31.4	4.2	
39.4	4.2	
49.4	4.2	
57.4	4.2	
1800.7	4.1	Mu
10.7	4.2	
17.7	4.3	
31.7	4.5	
35.8	4.6	

185634
Z Lyrae

1789.6	12.4	M

190108
R Aquilae

1689.6	6.2	Lt
1704.4	6.6	
12.5	6.7	
20.4	7.0	
31.4	7.4	
40.4	7.5	
49.4	7.8	
60.5	8.1	

R Aquilae

J.D. 242	Est.	Obs.
1781.8	8.7	M
91.7	8.6	B
1823.7	9.4	
33.6	9.3	Wh

190925
S Lyrae

1809.6	12.0	Ba
30.6	10.5	

190926
X Lyrae

1781.8	8.9	M

190967
U Draconis

1781.8	11.0	M

191019
R Sagittarii

1783.7	12.0	M
90.7	10.6	B

191033
RY Sagittarii

1699.7	7.1	δ
1702.7	7.0	
05.9	7.1	
18.7	7.1	
45.5	6.7	
50.9	7.1	
59.5	7.4	L
61.5	7.4	
61.8	7.4	δ
77.4	7.1	L
80.6	7.0	δ
83.4	6.8	L
83.7	7.0	
1800.4	7.2	
08.4	7.3	
09.6	7.3	Ba
30.5	6.3	
32.5	6.3	
33.5	6.4	
38.5	6.3	

191124
TY Sagittarii

1705.8	12.3	δ
61.9	13.1	
80.6	12.0	

191350
TZ Cygni

1777.7	11.2	M
1809.6	11.0	Ba
30.6	11.0	

191319
S Sagittarii

1751.5	9.9	Lt
56.5	10.5	
83.7	10.8	M

VARIABLE STAR OBSERVATIONS July, Aug., Sept., 1918—Continued.

191321
Z Sagittarii

J.D	Est.	Obs.
242		
1783.7	12.0	M

191717
T Sagittae

1776.8	9.7	M

192745
AF Cygni

1689.5	7.6	Lt
1704.5	7.4	
24.4	7.2	
27.4	7.2	
39.4	7.4	
49.4	7.4	

192928
TY Cygni

1689.6	10.0	Lt
1789.6	13.7	M

193449
R Cygni

1787.7	13.3	B
89.6	12.8	M
1803.6	11.2	Wh
04.3	11.4	Pe
07.6	11.1	O
08.6	11.2	B
09.6	11.6	Ba
20.8	9.4	M
30.6	10.0	Ba

193509
RV Aquilae

1832.6	9.8	Wh
38.6	9.4	O

193732
TT Cygni

1782.7	8.2	M
87.7	8.3	Pt
89.6	7.2	Hu
91.6	7.5	B
1805.7	9.0	Pt
20.7	8.0	M
35.7	8.2	Pt

193972
T Pavonis

1780.6	13.0	δ

194048
RT Cygni

1689.5	11.4	Lt
1720.5	9.4	
29.4	8.6	
40.4	7.9	
47.5	7.4	
61.4	7,3	
78.7	7.7	B

RT Cygni

J.D	Est.	Obs.
242		
1782.7	7.0	M
86.8	7.9	V
89.6	8.0	Hu
91.7	8.1	Mu
1803.6	8.6	Wh
05.6	9.0	V
07.6	9,0	O
08.6	8.9	B
12.7	9.7	Mu
17.7	9.8	V
20.8	11.0	M
30.6	10.8	Ba

194348
TU Cygni

1689.6	9.7	Lt
1704.4	9.7	
24.4	9.7	
32.4	10.3	
46.4	10.8	
61.4	11.2	
78.7	12.7	B
89.6	12.8	M
1812.7	10.5	Mu

194659
S Pavonis

1705.8	9.1	δ
50.8	7.9	
61.9	7.9	
80.7	7.2	

194604
X Aquilae

1689.5	8.5	Lt
1704.5	8.6	
24.5	8.9	
44.5	9.0	
61.4	10.1	
77.7	11.0	M
87.7	11.5	B
1809.6	12.9	
09.6	12.6	Ba
20.7	12.5	M

194632
χ Cygni

1689.5	4.7	Lt
1704.4	5.1	
12.5	5.3	
20.3	5.4	Pe
20.4	5.5	Lt
30.4	5.9	
31.3	5.9	Pe
39.4	6.4	Lt
40.3	6.4	Pe
47.3	6.9	
48.5	7.0	Lt
57.4	7.4	Pe
59.4	7.6	Lt

χ Cygni

J.D	Est.	Obs.
242		
1763.4	7.7	Pe
74.4	8.2	
82.7	9.0	M
86.8	8.3	V
87.7	9.1	Pt
89.6	8.4	Hu
91.6	8.8	B
1804.3	9.7	Pe
05.6	8.9	V
12.8	10.9	Mu
17.7	10.5	V
20.8	10.6	M
21.6	10.3	Wh
29.6	11.3	B

194929
RR Sagittarii

1705.8	9.3	δ
80.7	6.0	

195116
S Sagittae

1777.7	6.0	Mu
78.7	6.2	
81.9	5.7	
86.7	6.2	
87.7	6.3	
89.7	6.0	
91.8	5.7	
93.8	5.5	
94.8	5.5	
95.7	5.8	
96.7	6.0	
99.7	5.4	
1800.7	5.5	
01.7	5.8	
03.7	6.0	
07.7	5.7	
08.7	5.5	
09.8	5.5	
10.7	5.4	
11.7	5.7	
12.7	6.0	
14.7	6.2	
15.8	6.0	
17.8	5.5	
18.7	5.7	
19.7	5.9	
29.7	6.1	
30.7	6.0	
34.7	5.2	
35.8	5.5	

195849
Z Cygni

1689.6	10.8	Lt
1778.7	12.7	B
89.6	12.3	M
95.6	12.6	B

Z Cygni

J.D	Est.	Obs
422		
1809.6	13.2	Ba
20.8	12.3	M
30.6	12.6	Ba

200212
SY Aquilae

1694.6	10.6	Lt
1751.4	11.4	
61.5	11.7	L
78.7	11.8	B
83.7	12.3	M
1808.7	12.3	B
09.6	12.5	Ba

200357
S Cygni

1783.7	12.4	B
89.7	11.9	M
1803.6	11.7	Wh
18.6	10.0	B
20.8	10.2	M

200514
R Capricorni

1751.5	11.3	Lt
83.7	10.5	M

200647
SV Cygni

1782.7	8.5	M
89.6	7.8	Hu
91.6	8.2	B
93.8	9.2	Mu
1807.8	8.4	M
12.7	8.9	Mu

200747
RX Cygni

1793.8	7.9	Mu
1812.7	7.7	

200715a
S Aquilae

1689.6	9.4	Lt
1724.5	9.1	
49.5	11.1	
59.5	11.1	
78.7	10.8	M
90.6	9.9	B
1807.7	10.0	M
12.8	9.9	Mu
28.7	9.8	B

200715b
RW Aquilae

1778.8	8.8	M
90.6	9.2	B
1807.7	8.8	M
12.8	9.7	Mu
28.7	9.2	B

200812
RU Aquilae

J.D	Est.	Obs.
242		
1790.7	13.4	B
1809.6	11.8	Ba
30.6	10.8	
33.6	10.5	B

200916
R Sagittae

1751.4	9.4	Lt
61.5	9.1	
78.7	8.8	M
90.6	9.1	B
1807.7	8.8	M
12.8	8.9	Mu
28.7	9.2	B

200906
Z Aquilae

1751.5	9.9	Lt
58.5	10.6	
90.7	12.8	B

200938
RS Cygni

1689.6	8.5	Lt
1716.5	8.5	
27	8.5	
43.4	8.5	
46	8.2	Pe
49.5	8.3	Lt
52	8.0	Pe
59.4	7.6	L
60.5	8.3	Lt
69.4	7.7	L
78.7	7.8	M
90.4	7.3	L
1803.6	7.3	Wh
07.7	8.3	M
10.6	7.3	L
18.8	7.5	M
37.8	8.3	

201008
R Delphini

1715.5	11.7	Lt
77.4	10.6	L
83.7	10.1	B
88.6	9.9	L
92.7	9.6	M
1804.6	8.7	B
06.4	8.8	L
06.7	8.9	Pt
07.6	8.8	O
09.6	8.6	Ba
25.6	8.6	B
30.6	8.5	Ba
38.6	9.2	O

VARIABLE STAR OBSERVATIONS, July, Aug., Sept., 1918—Continued.

201130
SX Cygni

J.D. 242	Est.	Obs.
1782.7	12.2	M
83.7	12.6	B
1804.7	12.0	
18.8	12.0	M
25.6	12.0	B

201121
RT Capricorni

1779.6	7.2	L
90.4	7.9	
1835.7	8.1	Pt

201139
RT Sagittarii

1705.8	12.4	δ
50.8	12.8	δ
61.9	12.7	
80.7	12.3	

201437a
P Cygni

1748.4	4.9	Pe

201647
U Cygni

1689.6	8.2	Lt
1704.4	7.7	
20.5	7.7	
29.4	7.6	
35.4	7.5	
49.5	7.4	
82.8	7.2	M
93.7	6.5	Mu
1803.6	6.9	Wh
06.7	7.5	Pt
07.8	6.6	M
12.7	6.8	Mu
18.8	7.1	M
35.7	8.0	Pt

202240
U Microscopii

1750.8	12.8	δ
61.9	11.4	
80.7	8.9	δ

202317
W Delphini

1818.8	9.0	M

202539
RW Cygni

1778.8	8.6	M
90.8	8.5	
1803.6	7.8	Wh
07.7	8.4	M
18.8	8.2	
37.8	8.4	

202817
Z Delphini

J.D. 242	Est.	Obs.
1787.8	10.3	M

202946
SZ Cygni

1777.6	8.7	Ba
78.7	9.6	M
81.7	9.7	Pt
86.7	9.7	
89.6	9.9	Hu
91.6	8.9	B
1802.6	8.9	Ba
03.6	9.5	Wh
06.7	9.3	Pt
07.8	9.2	M
09.6	8.9	Ba
18.8	9.6	M
30.5	9.4	Ba
32.5	9.1	
33.5	9.0	
37.8	9.1	M
38.5	8.8	

202954
ST Cygni

1750.4	11.5	Lt
78.7	10.6	M
90.6	10.9	Hu
91.7	10.8	B
1807.8	10.5	M
18.8	10.6	
25.6	10.8	B
37.8	11.2	M

203226
V Vulpeculae

1783.6	8.9	Wh
87.8	9.1	M
1818.8	8 8	
21.6	8 8	Wh
35.7	9.1	Pt

203611
Y Delphini

1783.7	13.2	B
87.8	12.4	M
1809.6	13.6	B

203816
S Delphini

1694.6	8.8	Lt
1749.5	10.0	
60.4	10.3	
86.9	10.4	V
87.7	9.8	M
90.6	9.5	Hu
91.6	9.6	B
1803.7	9.7	Wh
05.6	10.3	V
17.7	10.3	
18.8	10.4	M
23.6	9.9	B

203847
V Cygni

J.D. 242	Est	Obs.
1689.6	8.9	Lt
1750.4	9.7	
78.7	10.3	M
87.6	9.1	B
1807.8	10.7	M
25.6	10.6	B

203905
Y Aquarii

1787.8	11.3	M
1805.3	12.4	P
06.3	12.2	

204016
T Delphini

1694.6	11.7	Lt
1749.5	10.6	
60.4	11.0	
87.7	12.2	M
90.7	12.0	B
1803.6	12.8	M
23.6	13.4	B
32.5	13.5	Ba

204017
U Delphini

1694.7	6.5	Lt
1750.5	6.5	

2005
T Aquarii

1749.5	8.7	Lt
58.5	8.1	
76.7	8.5	Pt
83.7	8.1	B
87.8	8.8	M
1805.3	9.8	Pe
06.3	9.8	
09.7	9.2	B
33.6	10.9	
33.6	11.2	Wh

204846
RZ Cygni

1789.7	11.3	M
1809.6	10.6	Ba
32.5	10.3	

205017
X Delphini

1778.7	13.7	B
1804.6	12.8	
21.8	10.5	M
37.8	10.4	

205030a
UX Cygni

1750.4	11.0	Lt
82.7	10.6	M
1821.8	11.8	

205647
RR Capricorni

1705.8	13.6	δ

205642
TX Cygni

J.D. 242	Est.	Obs.
1790.7	9.3	M

205923
R Vulpeculae

1685.6	9.3	Lt
1751.4	11.4	
58.5	11.1	
83.6	8.5	Wh
90.6	8.2	Hu
92.7	8.0	M
1814.7	8.8	Pt
21.6	9.5	Wh
21.8	9.0	M

210116
RS Capricorni

1788.8	7.9	M

210129
TW Cygni

1782.7	11.7	M
87.7	12.2	B
1809.6	12.7	
09.7	12.7	Ba

210812
R Equulei

1802.6	10.4	Ba
33.5	9.3	

210868
T Cephei

1686.5	8.1	Lt
1702.4	8.1	
16.5	8.3	
30.4	8.9	
41.4	9.2	
49.5	9.3	
53.4	8.9	L
61.4	9.5	Lt
73.4	9.4	L
88.6	10.1	
1803.6	9.9	O
06.8	10.6	M
19.6	9.4	B
34.6	9.3	
38.6	9.2	O

212030
S Microscopii

1705.8	9.9	δ

213244
W Cygni

1689.6	6.6	Lt
1704.4	6.5	
24.4	6.5	
29.4	5.9	Pe
31.4	6.5	Lt
44.4	6.5	
47.3	6.5	Pe

W Cygni

J.D. 242	Est.	Obs.
1749.4	6.4	Lt
58.4	6.5	
60.4	5.9	L
67.4	5.8	
73.4	5.9	
81.3	6.4	Pe
83.4	5.9	L
96.3	5.9	
1800.3	5.9	
03.4	5.8	
04.3	6.5	Pe

213678
S Cephei

1686.4	13.0	Lt
1750.4	11.8	
1809.7	9.7	Ba
18.6	11.2	B
34.6	10.0	O
36.8	10.5	M

213753
RU Cygni

1750.4	8.9	Lt
76.7	8.4	M
81.7	8.8	
90.7	9.1	
1816.9	8.8	M
33.5	9.6	Ba

213843
SS Cygni

1689.6	9.5	Lt
1743.4	11.3	Pe
44.4	9.3	Lt
44.4	11.3	Pe
45.4	9.9	
46.4	8.3	
47.4	8.3	
48.4	8.2	
49.4	8.4	Lt
49.4	8.3	Pe
50.4	8.3	
51.4	8.3	
52.4	8.3	
53.4	8.4	
53.4	8.9	L
57.4	9.3	Pe
58.4	9.6	Lt
58.4	9.4	Pe
58.4	9.1	L
59.4	9.8	Pe
59.4	10.0	L
61.5	10.1	L
63.4	11.0	Pe
64.8	11.9	Al
65.8	11.7	
66.8	11.7	
67.4	11.8	L
67.8	11.7	Al

VARIABLE STAR OBSERVATIONS, July, Aug., Sept., 1918—Continued.

213843
SS Cygni

J. D. 242	Est.	Obs.
1768.8	11.7	
69.8	11.7	
70.8	11.5	
71.8	11.5	
72.7	11.5	
73.4	11.5	L
74.4	11.7	
74.7	11.5	Al
75.6	11.6	Ba
75.7	11.6	Al
76.6	11.6	Ba
76.7	11.6	Al
76.8	12.2	M
77.6	11.6	Ba
77.7	11.6	Al
77.7	11.7	Wh
77.7	11.6	B
78.7	11.6	
78.7	11.6	Al
79.5	11.5	L
79.7	11.6	Al
80.8	11.6	
81.8	11.6	
82.8	11.5	
83.4	11.6	L
83.7	11.7	B
83.9	11.6	Al
84.7	11.6	
85.4	11.8	L
85.8	11.7	Al
86.8	11.7	
87.7	11.6	B
87.7	11.8	M
87.8	11.6	Al
89.6	11.7	L
89.7	11.7	M
90.4	11.6	L
90.6	12.0	Hu
91.6	11.6	B
91.8	11.6	Al
92.8	11.6	
93.7	11.6	B
94.6	11.8	
95.6	11.8	
97.8	9.9	Al
98.8	9.7	
99.8	9.1	
1802.6	11.6	B
02.6	11.4	Ba
03.4	11.7	L
03.6	11.6	M
03.7	11.8	Pi
03.8	11.9	Wh
04.3	11.9	Pe
04.4	11.7	L
04.6	11.2	B
05.7	11.0	V
06.3	11.1	Pe
06.4	10.6	L

SS Cygni

J. D. 242	Est.	Obs.
1806.8	10.6	M
07.4	10.0	L
07.6	9.8	B
07.6	10.0	O
07.7	10.0	Wh
07.7	9.8	M
07.7	9.7	Pt
08.3	9.4	L
08.6	9.6	B
09.6	9.1	Ba
09.6	9.0	B
09.7	9.0	Pt
10.4	8.2	L
10.6	8.3	V
10.7	8.3	M
10.7	8.7	Pt
11.7	8.3	M
11.7	8.6	Pt
12.6	8.4	V
12.6	8.7	B
12.8	8.5	M
12.8	8.4	Mu
13.7	8.7	Pt
14.7	9.0	
14.8	9.1	M
15.6	9.9	Wh
15.8	9.6	M
16.9	9.8	
17.6	10.2	V
18.6	10.6	B
18.8	10.7	M
19.6	10.9	
19.8	11.2	
20.7	11.6	
21.6	11.8	Wh
21.6	11.6	B
21.8	11.8	M
23.6	11.7	B
23.6	11.5	Bu
24.6	11.5	
25.6	11.7	B
25.6	11.5	Bu
27.6	11.7	B
28.6	11.7	
29.6	11.7	
30.5	11.4	Ba
32.5	11.8	
32.6	11.9	B
33.5	11.9	Ba
33.6	11.9	B
34.6	11.9	
36.8	12.0	M
37.6	11.2	V
37.7	12.0	M
38.5	11.7	Ba

213937
RV Cygni

J. D. 242	Est.	Obs.
1778.7	8.0	M
81.7	8.0	

RV Cygni

J. D. 242	Est.	Obs.
1787.7	7.9	Pt
89.6	7.5	Hu
90.7	8.2	M
1803.7	8.3	Pi
16.9	8.3	M
24.6	7.8	Bu
31.6	7.7	M

214024
RR Pegasi

J. D. 242	Est.	Obs.
1751.5	11.0	Lt
92.8	9.5	M
1807.6	9.6	B
33.6	10.9	
36.8	11.0	M

214247
R Gruis

J. D. 242	Est.	Obs.
1705.8	7.7	δ
50.8	9.0	
61.9	10.0	
80.7	10.0	

214443
WY Cygni

J. D. 242	Est.	Obs.
1751.4	11.2	Pe
57.4	11.0	
63.4	10.0	
1804.3	11.3	
06.3	11.1	

215605
V Pegasi

J. D. 242	Est.	Obs.
1792.8	10.4	M
1802.6	9.2	Ba
05.7	9.5	V
17.7	8.7	
19.6	8.9	B
33.5	8.7	Ba
33.7	8.5	B
36.8	8.7	M
37.6	8.6	V

215934
RT Pegasi

J. D. 242	Est.	Obs.
1792.8	11.0	M
1836.8	11.5	

220133a
RY Pegasi

J. D. 242	Est.	Obs.
1750.5	12.2	Lt
60.5	12.4	

220133b
RZ Pegasi

J. D. 242	Est.	Obs.
1750.5	11.8	Lt
60.5	11.7	

220412
T Pegasi

J. D. 242	Est.	Obs.
1761.5	9.8	L
85.4	10.2	
92.8	10.8	M
94.6	11.1	L
1802.6	11.4	Ba
07.6	12.0	B
33.5	12.5	Ba

220714
RS Pegasi

J. D. 242	Est.	Obs.
1807.7	12.5	B
09.7	12.7	Ba
33.6	12.9	

221948
S Gruis

J. D. 242	Est.	Obs.
1705.8	9.6	δ
50.8	7.8	
61.9	7.6	
80.7	8.0	

222439
S Lacertae

J. D. 242	Est.	Obs.
1689.6	10.9	Lt
1704.5	9.1	
24.5	8.5	
32.4	8.5	
39.5	8.6	
49.4	8.7	
88.6	10.0	L
1802.6	11.0	Ba
19.6	12.2	B
33.6	12.5	Ba
33.7	12.2	B

223462
T Tucanae

J. D. 242	Est.	Obs.
1705.8	11.2	δ
50.8	13.0	
61.9	13.5	
80.7	13.3	

223841
R Lacertae

J. D. 242	Est.	Obs.
1694.6	10.9	Lt
1724.5	9.5	
43.5	9.5	
53.4	9.6	

225914
RW Pegasi

J. D. 242	Est.	Obs.
1749.5	11.0	Lt
60.5	11.9	
1807.7	13.7	B

230110
R Pegasi

J. D. 242	Est.	Obs.
1752.5	13.2	Lt

230759
V Cassiop.

J. D. 242	Est.	Obs.
1689.4	8.7	Lt
1704.4	8.2	
24.5	8.6	
32.4	8.8	
40.4	9.1	
55.5	9.3	
53.4	9.7	Pe
57.4	9.4	
58.4	9.9	
83.7	10.6	B
88.8	11.2	M
1802.7	12.0	B
02.7	11.9	Ba
06.3	11.5	Pe
33.6	12.7	Ba

231425
W Pegasi

J. D. 242	Est.	Obs.
1761.5	9.6	L
79.6	10.2	
88.8	10.6	M
91.6	10.8	L
1802.7	11.0	Ba
33.6	12.0	

231508
S Pegasi

J. D. 242	Est.	Obs.
1805.4	12.4	Pe
09.7	12.7	Ba
23.7	12.4	B
33.6	12.5	B5
37.8	10.4	M

232746
V Phoenicis

J. D. 242	Est.	Obs.
1705.9	13.2	δ
50.9	11.8	
80.7	9.8	

233335
ST Androm.

J. D. 242	Est.	Obs.
1787.8	9.5	M
1807.7	9.5	B
23.6	10.4	Bu
28.7	9.9	B
34.6	10.4	Wh

233451
SV Cassiop.

J. D. 242	Est.	Obs.
1690.6	9.8	Lt
1724.4	9.8	
34.5	9.7	
43.5	9.7	
56.5	9.5	
1819.8	10.4	M

233815
R Aquarii

J. D. 242	Est.	Obs.
1788.8	10.0	M
1819.8	9.7	
37.7	9.8	

VARIABLE STAR OBSERVATIONS, July, Aug., Sept., 1918—Continued.

235150 R Phoenicis		235350 R Cassiop.			R Cassiop.			R Cassiop.			235855 Y Cassiop.	
J.D. 242	Est.Obs.	J.D. 242	Est.Obs.		J.D. 242	Est.Obs.		J.D. 242	Est.Obs.		J.D. 242	Est.Obs.
1750.9	7.6 δ	1689.3	6.9	Lt	1785.8	9.0	V	1837.6	10.3	V	1833.6	10.5 Ba
80.7	8.2	1704.4	7.5		87.8	9.0	M	38.6	10.0	O		
		20.4	8.0		1802.7	8.9	B					
		31.4	8.6		09.8	9.2	V					
235209 V Ceti		39.4	8.9		23.6	10.0	Bu	*235715* W Ceti			235939 SV Androm.	
1838.6	11.3 Ba	47.5	9.1		25.6	9.3	B	1837.8	9.0	M	1807.7	13.0 B
		78.7	8.4	B	33.6	9.6	Ba					

Summary.

	Aug.	Sept.
No. of Observations	1367	1163
No. of Stars Observed	289	346
No. of Observers	20	22

The following list is cited from Mr. Campbell's list of calculated dates of Maxima and Minima:—

Sept.	4	*022143* o Ceti	Max.	Oct.	10	154615	R Serpentis	Min.
	14	194048	RT Cygni	Min.		11	160210	U Serpentis	Max.
	15	001755	T Cassiop.	Max.		13	161219	U Herculis	Max.
	15	193509	RV Aquilae	Max.		15	081617	V Cancri	Min.
	18	235525	Z Pegasi	Max.		15	*204405*	T Aquarii	Min.
	23	222439	S Lacertae	Min.		16	*191019*	R Sagittarii	Max.
Oct.	3	072708	S Can. Min.	Max.		20	004958	W Cassiop.	Max.
	3	134440	R Can. Ven.	Max.		21	023133	R Trianguli	Min.
	4	081112	R Cancri	Min.		25	181136	W Lyrae	Max.
	6	021024	R Arietis	Max.		27	195849	Z Cygni	Max.
	7	084803	S Hydrae	Max.		30	162807	SS Herculis	Max.

In this and future reports an observer's abbreviation will be omitted where there are several of his consecutive observations recorded.

This report contains 400 observations of the Nova Aquilae made in a period of 78 days, which well attests the value of coöperative observing. The interesting and characteristic fluctuations in brightness are clearly shown in this record. The recent rapid rise of the variable *184205* R Scuti is one of the many interesting features of this report.

The annual meeting of the Association will be held at Cambridge, November 16. We hope to have a large attendance as there are many important matters to discuss

The following members contributed to this report: Messrs. Bancroft, Bouton, Burbeck, Dawson, Delmhorst, De Perrot, Francis, Gould, Jacobs, Lacchini, Luyten, McAteer, Meeker, Mundt, Murray, Olcott, Peltier, Reardon, Miss Reed, Vrooman, Whitehorn, Miss Young.

WILLIAM TYLER OLCOTT,
Secretary.

Norwich, Conn.
Sept. 10, 1918.

COMET AND ASTEROID NOTES.

Borrelly's Periodic Comet 1905 II was discovered at its third apparition by Fayet at Nice on August 7 in the following position:

Aug. 7.6205 G. M. T. R. A $3^h\ 39^m\ 52^s.0$, Dec. $-16°\ 14'$.

This announcement was made in the Harvard Bulletin 667. Bulletin 669 contains the following later observations:

	G. M. T.	R. A.	Dec.	Observer	Place
		h m s	° ′ ″		
Aug.	18.87500	4 05.4	−15 18	Barnard	Williams Bay
	31.89146	4 39 19.15	−14 01 50.0	Van Biesbroeck	" "
Sept.	5.91563	4 45 18.78	−13 29 47.4	Van Biesbroeck	" "

On August 31 the diffuse nucleus was elongated in position angle 95°. A short tail extended 49″ in the same direction. The comet was very faint, the magnitude being estimated at 13.

Ephemeris of Borrelly's Comet.—The enclosed ephemeris of Borrelly's comet is based upon elliptic elements copied from the August number of *The Observatory*. The elements are as below.

ELEMENTS OF BORRELLY'S COMET.

T = Nov. 16.65, 1918 G. M. T.
π = 69° 19′
Ω = 76 58
i = 30 43
e = 0.61530
log a = 0.55980
log q = 0.14494
μ = 513″.22

Greenwich Midnight 1918	α	δ	log r	log Δ
	h m s	° ′ ″		
Oct. 15	6 04 37	− 6 02 47	0.15934	9.89386
19	6 11 33	− 4 36 56	0.15608	9.87319
23	6 18 11	− 2 59 32	0.15320	9.85206
27	6 24 30	− 1 08 49	0.15072	9.83061
31	6 30 30	+ 0 57 31	0.14866	9.80905
Nov. 4	6 36 06	+ 3 22 13	0.14706	9.78763
8	6 41 17	+ 6 03 38	0.14588	9.76657
12	6 45 59	+ 9 06 52	0.14520	9.74651
16	6 50 19	+12 30 34	0.14492	9.72750
20	6 53 53	+16 16 15	0.14514	9.71082

CONSTANTS.

$x = r\,[9.93821]\ \sin\ (164°\ 55'\ 48'' + u)$
$y = r\,[9.95141]\ \sin\ (\ 91\ 37\ 40 + u)$
$z = r\,[9.82573]\ \sin\ (\ 35\ 23\ 14 + u)$

F. E. SEAGRAVE.

Elements of Borrelly's Comet 1905 II = 1911 VIII.—Circular S. 11, No. 29, of the Observatory of Marseilles contains the following elements of Borrelly's periodic comet, calculated by M. Fayet, of the Nice Observatory, which

are based upon some 400 observations made in 1911-12, and have been corrected for the perturbations of the first order by Jupiter and Saturn.

Date of osculation, 1918 Aug. 14.0 G. M. T.

$$
\left.\begin{array}{rcl}
M &=& 346^\circ\ 31'\ 41''.97 \\
\pi &=& 69\ 19\ 22\ .30 \\
\Omega &=& 76\ 55\ 52\ .86 \\
\omega &=& -7\ 36\ 30\ .56 \\
i &=& 30\ 29\ 27\ .28
\end{array}\right\} 1918.0
$$

$$\mu = 514''.03134$$

$$\phi = 37^\circ\ 57'\ 05''.78$$

$$T = \text{Nov. } 16.3466$$

According to Fayet's discovery position the ephemeris calculated by means of these elements requires the correction of -27^s in R. A. and $-8'$ in Dec., which corresponds to a correction of 0.35 day in the date of perihelion passage.

The ephemeris for the last five days of September is given herewith.

G. M. T.		R. A.	Dec.	log Δ	log r	$1{:}r^2\Delta^2$
		h m s	° ′			
Sept.	27	5 31 15	−10 10.8	0.17755	9.98044	0.483
	28	33 13	9 59.1			
	29	35 13	9 47.1			
	30	37 12	9 34.7			
Oct.	1	5 39 10	− 9 21.9	0.17291	9.96205	0.537

COMMUNICATIONS.

A Notable Meteorite.—The appearance, recently, of an exceedingly brilliant meteorite in Iowa and adjoining states, recalls to mind another celestial visitor, the fall of which I was fortunate enough to witness. This was the well known Amana meteorite which fell February 12, 1875, near the Communistic settlement in Central Iowa known as the Amana Society. At that time I was residing in Carroll county, Missouri, some two hundred miles southwest of Amana. About ten o'clock on the evening of the date mentioned above I was returning home from a neighbor's house and having reached the summit of a hill, commanding an extended view in all directions, I halted a moment to enjoy the splendor of the heavens and the scene about me. Facing the south and the full moon, which was near the meridian, I was suddenly aware of *my shadow moving steadily across the bright moonlight.* Turning quickly I beheld an intensely brilliant object descending in a wavy course toward the northeast, leaving a long, luminous trail behind it. I expected every moment to see it burst and disappear, the usual habit with meteorites, but it continued on and was soon lost to view behind the horizon. I made a mental note of the direction, feeling sure that I should soon see some allusion to an incident so unusual, in the daily papers. I was not mistaken, and a day or two later I read an account of the occurrence with more or less graphic details of the event. Just before reaching the earth the meteor burst, scattering the fragments over several square miles of territory. Eventually eighty-five pieces, ranging in size from a few ounces to one hundred pounds or more, were found. The meteorite was of the stony variety, almost black in color and of high specific gravity. Dr. G. D. Hinrichs, of the Amana Society, secured most of the specimens, but a few found their way into various museums and private collections in this country and abroad. The entire mass of the meteorite weighed approximately one thousand pounds.

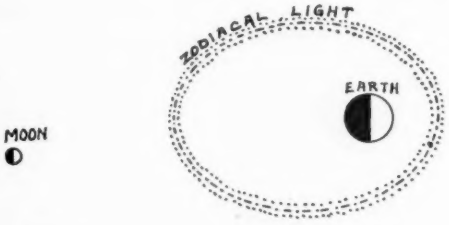
ARTHUR W. CROSBY.

U. S. Weather Bureau,
Boston, Mass., March 22, 1918.

The Zodiacal Light.—Certain criticisms which have reached me concerning my article on Zodiacal Light in the 1918 February issue of POPULAR ASTRONOMY are worthy of mention.

1. The objection is urged that if the earth's shadow lies across a section of the assumed earth ring the Gegenschein illumination would be impossible. My understanding of the condition is that for 100,000 miles from the earth's surface the shadow is absolutely dark, and, unless self luminous, no meteoric matter would be visible. But beyond that distance light reflected from the earth's perimeter would illuminate any meteoric matter within the shadow and would illuminate it according to Fresnel's law, i.e., more faintly at first; more intensely as the distance from the earth increases. The very faint Gegenschein illumination indicates that it is relatively near the earth.

2. The objection is made that if the Zodiacal Light be an earth ring it should lie in the plane of the earth's equator. To this I reply that the moon does not lie in the equatorial plane and that, so far as ascertained, the Zodiacal Light plane and that of the moon follow more nearly the plane of the ecliptic. If, as I suppose, the Zodiacal Light ring is within the moon's orbit, I suggest that the moon's gravitational influence (while not sufficient to disintegrate the ring) may control the plane of the Zodiacal Light.



3. It is urged that the broader Zodiacal Light along the horizons, E and W, cannot be accounted for by the optical illusion of the apparent enlargement of constellations near the horizon. I reply: Not altogether. The possibility is that the elliptical orbit of the assumed Zodiacal Light ring brings the portions of the ring nearest the E and W horizons nearer the earth and this possibility, in addition to the optical illusion mentioned, would account for the broadening of the illumination. The diagram given herewith illustrates my conception of the appearance of the ring.

W. E. GLANVILLE.

St. Peters' Rectory,
Solomons, Md. 1918 June 25.

Three Bright Meteors.—On the evening of August 6, 1918 at $9^h\ 5^m$ while observing Mercury I saw a meteor of the plus [minus ?] second magnitude not far from that planet. It passed over a path 6.6 degrees in length. This meteor was of an orange tint but, on account of its nearness to the horizon and the brightness of the sun's rays, proper observation, could not be made.

Five minutes later or at $21^h\ 10^m$ another meteor was seen as bright as Venus at quadrature. Only a few seconds later a third one was seen, appearing at almost the exact point in the heavens as the second. The second meteor appeared 4° southeast of Arcturus, traversed a path 36° long and was last seen about midway

between α and β Leonis. It was of the same color as Arcturus and left a flaming train of red in its wake. This is the brightest meteor seen in several evenings, giving as much light as the moon two or three days old.

The third meteor was of the minus first magnitude and described a path 25°.4 in length passing southwest from Arcturus. It was a pure white and left a train 7° or 8° in length. These three meteors are probably of the August shower and we may expect to see more in the next few evenings.

STERLING BUNCH.

Des Moines, New Mex., Box 195.

Soldiers Observe a Meteor.—Camp Hancock is located four miles south of Augusta. Nine or ten men from our company, including myself, were packing boxes at the head of the company street; packing boxes preparing for our departure abroad.

Suddenly an object flashed out in the northern sky and swept downward at a slow and lazy angle. For at least 80 seconds a dull orange colored streak could be seen. Then it quickly changed its color to pure white, and through 6 power field glass, I saw it roll together. Indeed it could be plainly seen with a naked eye. This white streak, extending clear to the earth, soon bent, combined into two small cloudlets, and drifted slowly away and out of sight.

CHARLES R. WEBER.

Co. C. 109th Machine Gun Battalion.

GENERAL NOTES.

American Astronomical Society.—The report of the August meeting of the American Astronomical Society, which was held at Harvard College Observatory, has not reached us yet, but will appear in the November number.

The Society for Practical Astronomy has decided to postpone further activity, including the publication of the *Monthly Register*, until after the war.

Dr. Francis Henroteau, who was Martin Kellogg Fellow in the Lick Observatory during the past year, has been appointed an assistant in the Allegheny Observatory, dating from July 1, 1918.

Dr. H. D. Curtis, of the Lick Observatory, is engaged in work connected with war problems in the Bureau of Standards, Washington D. C.

Mr. H. Thiele, Fellow in the Lick Observatory during the past year, has been appointed assistant for the coming year.

Dr. Ralph E. Wilson, Acting Astronomer in charge of the D. O. Mills Observatory in Santiago, Chile, for the past five years, has returned to the United States. He is now attached to the Division of Construction of Aeronautical Instruments, which has been recently moved from Washington, D. C., to Dayton, Ohio.

Dr. George F. Paddock, Assistant at the Lick Observatory, has been appointed Acting Astronomer in charge of the D. O. Mills Observatory at Santiago, Chile.

Visual Observations of the Eclipse of June 8, 1918, near Green River, Wyoming.—Realizing that the clouds were apt to obscure the sun at the time of totality, at the eclipse camp of the Yerkes Observatory, I started in my car to the northwest at 5:05 and traveled about five miles, to the top of a high mesa where a fine view toward the east and west could be had. At the scheduled time, 5:17, we saw the shadow approaching from the west, and it was soon upon us. Just before totality the corona showed around the sun. Jupiter flashed out east of the sun. The light reduced till it was difficult to read the time by a watch. A peculiar glow of yellowish light was seen on the clouds outside the shadow. To the east and west the corona showed distinctly, but no long streamers could be observed. I noticed that the streamers were shorter than those that appeared during the total eclipse of May 1900, which I observed near Norfolk, Va.

One noticeable phenomenon was the appearance of a large prominence, which showed throughout the period of totality. As the disk of the moon passed off to the east large prominences showed along the western limb of the sun.

Watching the shadow disappear to the east like a dark cloud, we distinctly saw on the white road the dark waves, at first distinctly and closely packed together, extending north and south, then becoming fainter and more widely separated.

The air became very noticeably colder and felt like the twilight air. I do not think the extent of the time or the intensity of the darkness would have caused chickens to go to roost, as a bird kept up its sound throughout the whole period.

The sight was one of great impressiveness and, supplemented by the quiet and extent of the desert, made it one never to be forgotten.

I would suggest that after this observing parties be provided with autos.

PERRY W. JENKINS.

[The above notes were written by Mr. Jenkins by request, at Camp Charles A. Young, the station of Yerkes Observatory, at Green River, less than half an hour after the eclipse. The writer was obliged to give up astronomical work on account of ill health, when he had a fellowship at the Yerkes Observatory some thirteen years ago. He has since thoroughly regained his health and is a successful stock-raiser at Cora, Wyoming. F.]

The Eclipse and the New Star in Japan.—Our University Observatory sent us to Torisima (St. Peter's I.) as the Solar Eclipse Expedition, (five persons in all), on June 9, 1918. The equipment consisted of four (refracting as well as reflecting) cameras, of which the largest was the concave mirror of five meters focal length, receiving the light-beam from a heliostat. Torisima is a very small volcanic island, the diameter being only a little more than one mile in every direction, and was very near to the central track of the total phase. It was our regret, however, that the first contact took place only four minutes after sunrise, and totality at an altitude of 10° 30′. These circumstances had threatened us from meteorological and also geographical points of view which at last attacked us severely; the gradual clearing up of the sky had scarcely reached the low horizon of the east when the eclipse began, so that observations of central totality had to be given up entirely, although several partial phases could be photographed. It is my decided impression that the darkness of the earthly scene during totality was not so intense as that of the usual full moon, as several observers had reported in many occasions. I do not know the cause of it.

Then on the night of 11th, the first clear night after the eclipse, Dr. Y. Ueta (Assistant) and myself made meridian observations for time and latitude with a universal instrument, during which we discovered a New Star in Aquila. The

circumstances were these: the sky gradually became cloudy when our transit observations ended at about 11 o'clock p. m., Standard Mean Time of Japan (9 hours earlier than Greenwich), so that only the brightest stars were left to us to observe the latitude, sufficient to be seen with our instrument. Then I turned from the meridian and caught the most convenient star of the first magnitude in order to observe its extra-meridian altitude. When it became necessary to write down the name of the star in our field-book, just after the visual observation was over, it suddenly struck me that this star was new! Then it occurred to me at once that this star had been seen since two or three hours before, during our transit observations, as a bright pair with Altair rising up from the east, though no particular impression was made until this moment. The star was very bright and bluish, and I visually estimated its magnitude as a little (about $0^m.1$) brighter than Vega, so that at that time the former was nearly equal to the latter to all appearances.

Next day at about 9 p. m. we got a glimpse of it when it stood about 10° above the eastern horizon. The light was less bluish and less bright; which can not be relied upon however, owing to its low altitude. After that it became thickly clouded

On the 13th we left Torisimo and arrived at Yokohama in the early morning of the 15th. Since then we have been constantly watching the sky. But it is my deep regret that the rainy season began on the 12th in our central Japan and consequently cloudy weather prevailed almost every day, allowing few chances for visual magnitude estimations. According, however, to these materials, we see that the star rapidly became fainter and redder until the 29th inst., when it suddenly began to rise again, promising some future fluctuations. Further notes will follow later.

I. YAMAMOTO, D. Sc.
Lecturer on Astronomy of the College of Science, Kyoto University, Japan.

Kyoto University Observatory,
June 30, 1918.

Hyderabad Astrographic Catalogue.—The first volume of this catalogue, which has just come to hand, contains the measured rectangular coördinates of 63436 star-images on plates with centers in declination −17°. This is a part of the zone originally assigned to the Santiago Observatory, Chile, and afterwards divided between Santiago, Hyderabad and LaPlata. The measures are presented in the same form as those of the Oxford Observatory.

The Orbit of Sirius.—In the *Lick Observatory Bulletin* No. 316, Professor Aitken gives a new determination of the orbit of the companion to Sirius, based upon all the available observations from 1862 to 1918. The companion has made somewhat more than a complete revolution around its primary in that interval, so that the new elements are very exact. The period comes out almost exactly fifty years, the small excess of .04 year being within the probable error of the result.

ELEMENTS.

P =	50.04 years	±0.09 years
T =	1894.133	±0.011 years
e =	0.5945	±0.0023
a =	7″.570	
i =	43°.31	±0°.25
ω =	145 .69	±0 .38
Ω =	42 .71	±0 .33

The following ephemeris will be useful to observers for the next quarter of a century:

EPHEMERIS OF SIRIUS.

Date	P. A.	Dist.	Date	P. A.	Dist.	
	°	″		°	″	
1919.24	68.9	11.14	1935.25	33.1	8.09	
21.24	65.1	11.30	36.24	29.2	7.48	
23.24	61.4	11.36	37.24	24.4	6.79	
25.24	57.6	11.23	38.24	18.5	6.03	
27.24	53,7	10.97	39.24	10.8	5.19	
29.24	49.5	10.55	40.24	360.0	4.30	
31.24	44.9	9.94	41.24	346.6	3.43	
32.24	42.4	9.57	44.173	349.1	2.83	Periastron
33.24	39.6	9.14	46.173	202.9	3.61	
1934.24	36.6	8.65	41.173	185.6	3.87	

Professor Aitken has investigated the measures of radial motion of Sirius and concludes that "up to the present time we have no definite evidence in either the micrometric or the spectrographic measures of Sirius that the observed motion departs from undisturbed elliptic motion."

Nova Aquilae III.—The new star has waned slowly during the past two months, with some fluctuations. It is still visible to the naked eye, but is not at all conspicuous, being now somewhere near fifth magnitude. Our readers will be interested in Professor Barnard's article in this issue of POPULAR ASTRONOMY, concerning reported naked eye observations of the nova prior to June 8, and in the long series of estimates of magnitude of the star contained in the monthly report of the Variable Star Association.

Professor Frost, director of the Yerkes Observatory, has very kindly sent us a print from a recent photograph of the nova, which will be very useful to those who wish to follow the changes of the star with low power field glasses. This photograph (Plate XXIV) was taken with the apochromatic-planar lens of the Yerkes Observatory sky patrol, seven millimeters out of focus. The fainter star images are suppressed, because the light is spread out so much in the out of focus image, so that only stars down to the seventh or eighth magnitude are shown.

Professor Moye of Montpellier sends in the following list of estimates from June 22 to September 2.

NOVA AQUILAE (1918).

June	22	2.4	July	4	3.7	July	19	3.8	Aug.	6	3.6	Aug.	17	4.0
	23	2.6		5	3.0		26	3.6		7	3.6		24	4.3
	24	2.6		6	3.1		27	3.6		8	3.8		25	4.4
	25	2.8		7	3.3		28	3.6		10	3.7		26	4.4
	27	3.4		11	3.6		29	3.5		11	3.7		27	3.8
	28	3.3		12	3.7		30	3.6		12	3.7		29	4.0
	29	3.4		14	3.5		31	3.6		13	3.8		30	4.2
	30	3.4		16	3.7	Aug.	3	3.8		14	4.0		31	4.4
July	1	3.4		17	3.8		5	4.0		15	4.2	Sept.	2	4.7
	3	3.0		18	3.8									

COMPARISON STARS (from H. P)

γ Aquilae	= 2.8	θ Serpentis	= 4.1
δ "	= 3.5	F14 Aquilae	= 5.0
β "	= 3.8		

Professor Pickering has very kindly sent, at our request, copies of the Harvard photographs of the nova on June 7 and 8. These are reproduced in plate XXIII for comparison with Professor Barnard's photographs in Plate XXII.

PLATE XXIV

N

THE REGION AROUND NOVA AQUILAE III, SEPT. 5, 1918

Photographed 7 mm. out of the focus of the apochromatic-planar lens of the Yerkes Observatory sky patrol.